



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

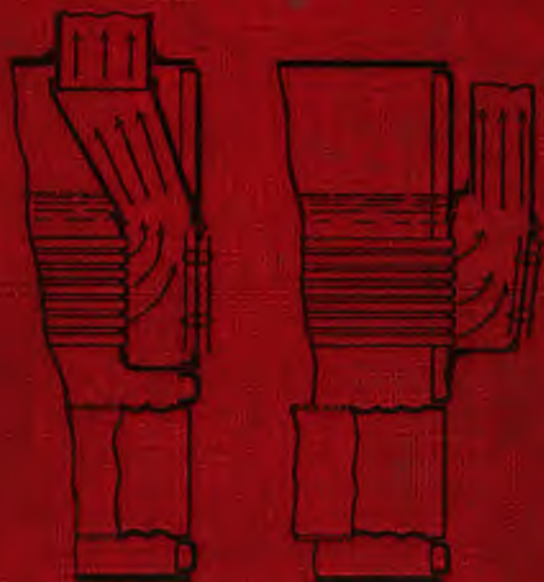
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

S
A
NE
RS
RN

BROWN'S
ELEMENTARY QUESTIONS
AND ANSWERS
FOR
MARINE ENGINEERS



W. T. THORN
Contains Alternative Questions

8/- NET.

N

Library
of the
University of Wisconsin



**BROWN'S
ELEMENTARY QUESTIONS AND ANSWERS
FOR MARINE ENGINEERS**

THE
JOURNAL OF THE
ROYAL ANTHROPOLOGICAL INSTITUTE
OF GREAT BRITAIN AND IRELAND
PUBLISHED BY THE
EDUCATIONAL SOCIETY OF GREAT BRITAIN

BROWN'S Elementary Questions and Answers

FOR MARINE ENGINEERS
TOGETHER WITH ALTERNATIVE QUESTIONS

BY

W. T. THORN

ERRATA.

- Page 7. 13 lines down, read which does not repeat
„ 102. 13 lines up, for leaving 4 tons, read 3 tons and alter where necessary.
„ 148. Q. 7. In the proportion for 355,722, read 355,794 and alter where necessary.
„ 138. Q. 10. The stroke in this question is 20 ins., not 18.
„ 161-2. Q. 8. In cubic contents of flanges insert 2·5 ins. as a multiplier. The cubic inches are then 689·5 and 906. On page 162 the total cubic inches are increased to 11,533·3 and the weight is then 3,001·5.
„ 166. Last line, insert, loss of efficiency is $\therefore 100 - 44\cdot65 = 55\cdot35$ per cent. — *Ans.*

GLASGOW

JAMES BROWN & SON, Nautical and Engineering Publishers
52 TO 58 DARNLEY STREET

1916

D. VAN NOSTRAND COMPANY

NEW YORK

265150
APR 11 1928

T JF
T39

6 966175

PREFACE

THE Publishers and Author have pleasure in bringing before marine engineers this up-to-date work dealing with the Elementary Questions and their Answers as required by the Board of Trade. They do this in the hope that its features of novelty may serve to render candidates for examination more certain of success in this section of their work, and special attention is drawn to the "additional" or "alternative" questions written by the Author in an endeavour to show how the older setting may be presented in new form, that in many cases calls for no further explanation or answering, and he has thought such changing would prove acceptable in view of the Regulation coming into force in January, 1917, which states "candidates may receive questions of a *similar nature* to those embodied in the original 310." It is not intended that these alternative questions be looked upon as ones that will certainly be given, but are only to show what *can* be done in the process of turning about.

Other valuable features of this work are the number of plates of various engine parts, etc., drawn without a confusion of fine details in order to leave the fundamental principles clear, also an extensive alphabetical index, contents, etc., which it is hoped will prove of use to those studying from this book.

The Author has refrained from giving elaborate notes upon all the various questions, as his experience has shown that readers prefer to see exactly what shape and approximate size their answer to an individual question should take, and he trusts those using this work will profit by its being written in a manner closely following that so successfully adopted in his Academy.

The Author and Publishers acknowledge with grateful thanks the loan of blocks, etc., from the following firms, and without which much valuable information could not have been given :—Messrs Weirs, of Cathcart, Glasgow; Parsons Motor Company, Southampton; Brazil, Straker & Co., Bristol; Holmes & Co., Newcastle-on-Tyne; Hall & Co., Dartford, Kent; Beldam Packing & Rubber Company, London;

Murray, McVinnie & Co., Glasgow; Railton, Campbell & Crawford, Liverpool; Aspinall's Governor Company, Liverpool; Kerr's Governor Company, Belfast; Davy Bros., Sheffield; Auld & Sons, Glasgow; Crosby Gage & Valve Company, London; Institute of Naval Architects, London; Parsons Marine Steam Turbine Company, Wallsend; Cockburn & Co., Glasgow; Drysdale & Co., Glasgow; Edward's Air Pump Syndicate, London; Smith's Dock Company, North Shields; Howden & Co., Glasgow; Babcock & Wilcox, London; Trewent & Proctor, London; Alley & McLellan, Glasgow.

W. T. THORN.

72 RAVENSWOOD ROAD, HEATON,
NEWCASTLE-ON-TYNE.

NOTICE TO ALL CANDIDATES FOR EXAMINATION

IN the pages following are given the 310 elementary questions and the necessary answers to the same. Care has been taken to make the latter as complete as is required, and all candidates are warned not, under any circumstances, to answer these questions curtly or by a mere yes or no. Let their answers be as full and complete as they can make them, without using a lot of words needlessly, and be sure to confine themselves to the question asked, and not to wander off from one thing to another. Remember that after January, 1917, the questions one has to answer at the examination will not always be taken from these 310, but may be others of a similar type, and in order to let readers of this book see something of what they may expect, we have added "alternative settings" to many of the questions. These are only put in as examples and must under no circumstance be taken as exactly what a candidate will receive, but he may rest assured that if he does not get the old setting, the new one will be off and on upon the lines we have shown. The answers to these are necessarily short and only inserted to show the lines on which to answer at greater length, as usually that given to the original questions does just as well.

Where it has been thought necessary, blocks of various makers' specialities have been inserted, and concise descriptions of these same have been added by the author, but candidates will carefully remember such additional information is not necessarily to be incorporated with the actual answer as has been set forth. The explanations are given in order to render the candidate's mind clearer and so that he may be in a position to make the required answer in as lucid and complete a manner as possible. Remember at the examination one really only gets a matter of 4 or 5 hours in which to answer the 10 questions, as the remainder of the 6 hours (maximum time allowed) is taken up by writing an account of where shop experience was gained, the kinds of boilers and engines one has been with, and, lastly, an account of the defects coming under the candidate's notice, both with engines and

boilers. He must therefore carefully think over what he intends putting down as his answer, and how he can do this in the clearest manner and without dragging things to undue lengths. At this point we impress upon every candidate the absolute necessity of his mastering the whole subject, of which the given "old" elementary question may be a part, so that he may be as able as possible to answer its alternative settings. This means a good deal more work, we know, but as the new regulation of the Board of Trade is evidently intended to test more completely the thoroughness of a man's knowledge, it is obvious he must possess this greater acquaintance with the matter he is expected to write upon, otherwise his chances of passing are remote.

Wherever possible—and the candidate knows he can manage to do so properly—let him use sketches to illustrate his writing and help in making the meaning of this still clearer. They need not be elaborate sketches, as often a few lines, *correctly* drawn, convey more than an hour's work on a "pretty" drawing.

Do not fall into the error of thinking that the more one writes the more one is likely to be asked, as the author's years of experience have invariably shown it to be exactly the other way about, and a moment's thought will show that naturally the less there is written about anything the *more* the examiner at the "verbals" is bound to ask a candidate in order to see if he knows really the ins and outs of the subject that he has scantily written upon.

CONTENTS

ELEMENTARY QUESTIONS

	PAGE
1. What parts of an engine are generally made of wrought iron? ...	I
2. What parts of an engine are generally made of cast iron? ...	I
3. For what parts of an engine is steel sometimes used? ...	I
4. What parts of an engine are generally made of brass or gun metal? ...	2
5. Where is "white metal" sometimes used? On account of what property possessed by it is it adopted? What objection is there to its more general use? ...	2
6. For what parts is Muntz metal sometimes used? Is it malleable? For what properties is it valued? ...	2
7. What difference is there in the composition of cast iron, of wrought iron, and of steel? ...	3
8. How can cast iron, wrought iron, and steel be distinguished from each other? ...	3
9. What are the different properties of cast iron, of wrought iron, and of steel?	4
10. What is meant by the terms, "breaking stress," "proof stress," "safe working stress"? ...	5
11. What is the cohesive strength, or breaking stress, of good ordinary wrought iron? ...	5
12. Tempering steel; how is it done, and in what order do the colours come?	5
13. What is case-hardening? ...	6
14. Which of the common metals or alloys can be forged, and which of them are brittle or "short"? ...	6
15. What is meant by "welding"? Which of the common metals can be welded? ...	6
16. The expansion of metals by heat; give examples of this in the engine and in the boiler. ...	7
17. In the construction of steel cylindrical marine boilers, for what parts have the plates to be worked hot? What precautionary treatment of these plates is afterwards necessary? ...	7
18. In what parts of cylindrical marine boilers is the strongest riveting employed? In which of the shell seams is it most necessary? ...	9

CONTENTS

	PAGE
19. What is "caulking," and how are seams prepared for caulking? ...	9
20. Describe the different ways of fastening the ends of the main stays of a boiler. What are the merits of, or objections to, the different plans?	10
21. What stress per square inch is allowed on boiler stays? ...	11
22. Describe a riveted stay, and state where such stays are commonly used. ...	12
23. Where are thin plates to be looked for in a boiler as it wears, and how is the thinness to be detected? ...	12
24. How are boiler tubes fixed? What are "stay tubes," and how are they secured? ...	13
25. Where is it generally that boiler tubes leak? How is this defect repaired? What are the causes of this leaking? ...	14
26. What are the causes of cracked tube plates? Where are the cracks situated? How are they repaired? ...	14
27. What is the difference between a "dry uptake" and a "wet uptake"? Which requires more repair? Why? Where have you seen a wet uptake? ...	16
28. What is a superheater? What is its construction? What valves are on it? There is sometimes a gauge glass on it; what is that for? Are superheaters now in general use? ...	17
29. What parts of a marine multitubular boiler are first injured by shortness of water? ...	18
30. Where are angle irons sometimes used in the construction of a boiler, and where are flanged plates used? ...	18
31. Priming; to what causes is it attributed? What means are applied to prevent it? What evils may be produced by it? ...	18
32. Funnel draught; what makes it? What checks it? ...	21
33. Flame is sometimes seen at the top of the funnel; what causes this appearance? Is it beneficial or is it detrimental? Why so? ...	21
34. A blast pipe; what is its construction? Where is it placed? For what is it used? ...	22
35. How many bottom blow-off cocks are generally fitted to each boiler, and why are they so fitted? ...	22
36. Blow-off cocks are sometimes fitted with a spanner guard; for what purpose is this? Describe how the guard is formed. ...	22
37. Water-gauge test cocks; where are they placed? At what heights? Must the cocks themselves be at those heights? What provision is made for cleaning these cocks should they ever become choked? When there are no test cocks how is the height of the water ascertained? ...	23
38. What is a deadweight safety valve? Of what are the rubbing surfaces formed? How is a lock-up valve arranged to admit of lifting it or of turning it round, and to prevent adding to the weight? ...	23

CONTENTS

x1

PAGE

39. About what area of safety valve is now required by the Board of Trade? What is the effect of suddenly opening a safety valve when steam is up? To about what extent do safety valves rise when blowing off without being eased by hand?	25
40. Spring-loaded safety valves; what advantages have they that are not possessed by deadweight valves? What are the disadvantages, if any, as compared with deadweight valves?	25
41. Of what pieces does a glass water gauge mounting consist? How does it act? Where is it placed? At what height? Is it liable to derangement? How is its working tested?	26
42. Glass water gauges have sometimes pipe connections top and bottom; what is the object of this arrangement? Should there be cocks at the extremities of these pipes? Why? or why not?	26
43. Describe a Bourdon steam gauge. Some gauges have an inverted syphon pipe below them; what is its use?	28
44. Why is a small cock sometimes put on the pipe leading to a steam gauge? Where should it be placed, and what error might be made by omitting to use it?	29
45. Do steam gauges indicate the total pressure of the steam or only a portion of that pressure? What is the pressure measured from?	30
46. What is meant by the salting of the boiler? How is this prevented? What is the density of ordinary sea water? How is the density ascertained? What is the difference between the formation of scale and the salting of the boiler? What is the maximum density at which boilers should be worked at sea? In the event of condenser tubes leaking what is the minimum density at which boilers should be worked? Give your reasons.	30
47. Scum cocks and pipes; how are they arranged? Where are they placed? At what height in the boiler? When are they used? When must they be shut? Neglect of these cocks leads to what dangers?	31
48. Of what does scale consist? Where is it most objectionable? How is it removed? How is its formation prevented? What evil effects are produced by it?	32
49. What is a salinometer? Of what does it consist? How does it act? How is it graduated? Can it be used at any temperature indiscriminately?	33
50. What harm may be done through the check valve of one of a set of boilers being defective while under way? How would you work to avoid this harm?	35
51. How is the leak from a split tube stopped in a boiler at sea? Describe the operation.	35
52. What is the use of dampers? Where are they fitted? When should they be used?	36

	PAGE
53. When there are no dampers fitted what is used instead? What evil to the boiler is sometimes attributed to this? When the heating surfaces are clean does this occur?	37
54. Describe the piston of a steam cylinder, with its different rings and their uses. There are generally round pieces let in flush on one side of a piston; what are they? How are these pieces fixed?	37
55. Cylinder drain cocks; what is their use? There is sometimes a valve upon each cock; what purpose does it serve?	38
56. Cylinder escape valves; of what do they consist? How protected? How regulated? When are they most needed? To what danger do they expose the engineer? What precaution is sometimes used to obviate this danger?	38
57. What is a compound engine? What different kinds are there for screw steamers, in respect to the number and arrangement of their cranks and cylinders? What is a triple expansion engine?	40
58. What is link motion? What are some of its advantages? In modern engines for the screw propeller when there is no link motion, what takes its place?	42
59. What is a separate expansion valve? Why is it not fitted to all engines? What effect has an expansion valve upon the starting and upon the reversing of the engine?	42
60. What arrangement is applied to reduce the friction of a slide valve? To what is the friction due?	44
61. Describe a loose eccentric; how does it act? In what engines are the loose eccentrics still employed?	45
62. What is the travel of the eccentric rod? How is it measured on the eccentric? What is the travel of the slide valve when the link motion is in mid gear, and the engine still moving?	46
63. What are "double beat valves"? What objections are there to their use?	47
64. What is a circulating pump? Is it always worked by the main engine? Give an example from your last steamer of the three water temperatures generally noted by careful engineers.	48
65. An air valve is sometimes fitted to a circulating reciprocating pump; what purpose does it serve?	50
66. What is the difference between a bucket air pump, a piston air pump, and a plunger air pump?	50
67. Are double-acting air pumps made with plungers, with pistons, or with buckets? Describe the construction and action of circulating pumps.	51
68. What is an air pump trunk? When is it necessary? How is it attached to the bucket? Centrifugal pumps; describe their construction, and mode of working.	51
69. What class of air pump requires both foot and delivery valves, and in what other class can either of these valves be in some cases dispensed with?	53

CONTENTS

xiii

PAGE

70. What are marine governors? What is their general construction? How do they act?	55
71. With a surface condenser and a single acting air pump what is the effect of a leaky foot valve, and what is the effect of a leaky bucket when there is also a foot valve?	59
72. Where is the air pump pet cock or valve placed? How does it act? What is its object? Does it in every case reduce the effective capacity of the pump? Is it equally applicable to double-acting pumps? ...	59
73. At what temperature is the hot well worked? What is the effect of higher temperatures? What is the effect of lower temperatures? What limits the lowness of temperature? Has a very low temperature any disadvantages?	60
74. Bilge injection with jet condensers; what are the fittings required? When is it used? What precautions are necessary in using it? ...	60
75. When surface condensers are used what takes the place of the bilge injection? To what is the connection made? How is its valve formed? Why is this necessary?	61
76. What are the practical guides to the proper amount of opening of the inlet valve for the circulating pump?	62
77. Feed pump pet cock or valve; where is it placed? What is its use? How does it act? Is it always a necessary fitting?	63
78. What are some of the ways of fastening the ends of surface condenser tubes? About what size and about what thickness are condenser tubes? What parts of a surface condenser are made of brass? ...	63
79. What is a blow-through valve or cock? To what is it attached? There is sometimes a valve which, when opened, admits steam from the slide valve casing to the exhaust port; what is its use? To which cylinder is it fitted?	64
80. What are snifting valves? Why are they generally omitted now? ...	65
81. What connections are generally fitted to the donkey pump, and to what services can it be applied?	65
82. When the engines are stopped in harbour with steam up, what are to be shut and what are to be opened?	66
83. How is an engine heated up before starting? What precautionary examinations are made before starting?	66
84. What is an interceptor or catch-water? Where is it fixed, what is its construction, how does it act, and what attention does it require? ...	67
85. Describe an air pump bucket, with its valve or valves and its packing. Of what are the valves generally made?	68
86. Of what materials are air pump rods made? Why?	68
87. What is the racing of the engine? When does it occur? What danger attaches to it? What is done to prevent it?	69

	PAGE
88. When under way, when the air pump bucket is at the top of its stroke at what height is the water in the condenser?	69
89. What is meant by the "pitch" of a screw propeller? How is it measured?	70
90. Explain the difference between a "right hand" and a "left hand" propeller, and state how each of them revolves.	71
91. What is the slip of a screw propeller? How is its amount expressed in figures?	72
92. Which of the valves about engines and boilers have to be worked by hand, which of them are self-acting, and which are worked by the motion of the engine?	72
93. Why is soda sometimes put into a boiler, and how is it put in when under way? What is the kind of soda used?	73
94. Tallow cups for cylinders were sometimes made with two small cocks, or with only one small cock, or with one large hollow plug cock, or with one small cock and a valve; which of these is suitable for a high pressure cylinder, and which for the cylinder of a condensing engine? Describe how the cup with only one small cock is used. What is now generally used instead of these? How has this change come about?	73
95. Does a cylinder escape valve, self-acting, allow all the water to escape? If not, how much is left in the cylinder?	74
96. What is a "steam lubricator" (sometimes called an impermeator)? Explain its action. To what part of the engine is it connected? Will throwing cold water over it make it work faster or slower? Describe the one used in your last steamer.	74
97. A common paddle wheel; of what is the centre made? Of what are the arms formed? What is the form of the bolts which attach the floats to the arms? How are the arms attached to the centres? ...	76
98. Why have some paddle wheels one or more cast-iron floats in each wheel? With what engines are these most required? At what part of the circumference are they placed?	77
99. Why are paddle wheel floats sometimes made of different breadths in the same wheel? With what description of engine is this most needed? Where are the broad floats placed and where are the narrow floats placed in the circumference of the wheel?	77
100. What difference is there between a radial paddle wheel and one with feathering floats? What is the object of feathering floats? Are all the eccentric rods attached in the same way, and are they all of the same form?	78
101. Whereabout is the centre of the eccentric of a paddle wheel with feathering floats placed? In that case are the feathering levers on the striking face or on the back of the float? When the paddle shaft has an outer bearing how is the eccentric made?	79
102. Of what materials are the working surfaces of a paddle wheel with feathering floats? How are they lubricated?	80

CONTENTS

XV
PAGE

103. What is a "disconnecting paddle engine?" At what place is the disconnecting effected? How is it accomplished? In which of the cranks of a disconnecting engine are the crank pins fixed? ...	80
104. Is link motion valve gear or the loose eccentric generally used for disconnecting paddle engines? For what steamers are disconnecting paddle engines frequently employed? ...	81
105. What are expansion joints? Where are they necessary? What attention do they require? Of what should the working surfaces be made? ...	82
106. What omission in the construction of expansion joints may lead to a serious accident when steam is first applied? How is this prevented in the construction of a steam trunnion pipe for an oscillating engine? ...	83
107. Describe an oil cup with a syphon worsted? How is the worsted arranged? How is it cleaned? How far down the tube does it extend? ...	84
108. Describe a thrust bearing; which of the surfaces wears? Why is there sometimes a number of oil tubes for one thrust bearing? ...	85
109. What parts of a screw shaft are generally covered with brass? Why is this necessary? About what thickness is the brass? ...	87
110. What is the stern tube or screw shaft pipe? Why is a pipe of such a length required? Of what is it made? How is it fixed at each end? ...	89
111. What is a <i>lignum vita</i> bearing? How is the wood fitted? Where is such a bearing generally used? ...	89
112. How is a screw propeller fixed on the shaft? What means are used to prevent its getting loose at sea? ...	90
113. Where are sluice valves placed? What large sluice valve is there in almost all screw steamers? From what position should this valve be worked? Why so? What attention should it receive? ...	91
114. With a condensing engine what valves or cocks are on the skin of the ship in the engine room and in the stokehold? ...	91
115. What are the necessary fittings of a marine boiler? ...	91
116. With a surface condensing engine what cocks or valves are opened some time before the engine is started so as to be ready for starting whenever the order is given? ...	92
117. What is a steam jacket? What cocks are on it? In what engines are jackets most generally used? Do they require to be felted? ...	92
118. What parts of an engine or its fittings should be felted or otherwise protected from radiation? ...	93
119. What are the small cylinders sometimes fitted on the slide valve casing cover of vertical engines? Explain their action. To what are they connected by a pipe? Why? ...	94
120. Name the principal pipes in connection with the engines and boilers of a steamer, and state to what the ends of these pipes are connected.	95

	PAGE
121. Through what cocks or valves, pipes and chambers does the water pass on its way from the sea inlet rose plate to the water space of the boiler, with a jet condenser?	96
122. Through what cocks or valves, pipes and chambers does the circulating water of a surface condenser pass?	96
123. Through what cocks or valves, pipes and chambers does the steam pass from the boiler until it is in the form of water in the hot well? ...	97
124. Name the pieces of the engine through which the pressure of the steam is transmitted from the piston to the screw propeller. Name them in the order in which they act.	97
125. What is an air vessel? How does it act? At what parts of an engine or of its fittings are air vessels generally applied?	98
126. What is the construction of a mudbox? Where should mudboxes be placed? Why are they necessary? How should the space be divided by the rose plate, and why?	99
127. What is a trunk engine? Why has it fallen into disuse?	100
128. What is an oscillating engine? For what steamers are oscillating engines generally adopted? Why? How is the steam conveyed to and from the slide valve casing?	101
129. Of what parts does the valve motion gear of an oscillating engine consist? ...	101
130. For what have geared engines sometimes been used? Of what were the cogs of the large wheel made?	102
131. At what part of a screw steamer is the pressure that propels it applied to the hull?	102
132. At what part of a paddle steamer is the pressure that propels it applied to the hull?	103
133. About how much fuel per indicated horse power per hour is required by modern steam engines, common, compound, and triple expansion? ...	103
134. What is the explanation of the economy of the surface condenser? ...	103
135. What is the construction of a surface condenser? Of what are its tubes made? How are they fixed? How are they kept tight? What is done with a split tube?	104
136. Where do surface condensers foul? How are they cleaned?	105
137. What non-conducting substances are employed to prevent radiation, and how are they applied?	105
138. In the construction of smoke-box doors and of dry uptakes, what provision is made to lessen the amount of radiation?	106
139. How can the formation of black smoke be prevented? Describe smoke-preventing apparatus.	106
140. What is meant by "circulation" in a boiler, and what are the results of defective circulation?	107

CONTENTS

xvii

PAGE

141. What means are sometimes adopted to improve the circulation in a boiler?	107
142. By what arrangement is the circulation promoted in a "hay-stack" boiler?	108
143. Describe a ship's side air pump discharge valve. In what respect does it sometimes differ from a common stop valve, and what attention does it require?	110
144. What is the construction of a feed escape valve, to what is its discharge connected, and how is its loading regulated? Where should the escaping water flow?	109
145. When there is no feed escape valve what is the arrangement of the feed valves or cocks?	112
146. What is the measure of a horse power? How is indicated horse power ascertained?	113
147. Has "nominal horse power" a fixed meaning? What is the use of this expression? What is generally taken as the measure of one horse power nominal?	113
148. What is "back pressure" in a cylinder? About how much is it in each of the cylinders in your last steamer? Is excessive cushioning ever a trouble under certain conditions in modern engines? Say when and why and in which cylinder this occurs.	114
149. What is meant by "speed of piston"? About how much is the speed of piston in modern marine engines?	114
150. What is "atmospheric pressure"? What is its average amount? What instrument tells this amount?	115
151. What is "gross pressure" or "absolute pressure"? What pressure is it that is shown by the steam gauge?	115
152. What is meant by "cutting off" steam? How is it done? What part of the valve regulates the cut off?	115
153. What is a piston slide valve? Describe its construction. Why are they frequently employed in place of the common slide valve? Have they any disadvantages compared with a common slide valve? If so, name them.	116
154. What fixes the time of closing the exhaust? After the exhaust is closed and before the port opens for steam, what becomes of the steam that is in the cylinder?	117
155. What is the "lead" of the valve? What is its object? About what amount is it?	118
156. What is the "cover" or "lap" of the valve? What is its object? About what proportion of the stroke of the valve is it made? ...	119
157. What is the "exhaust cover" of a slide valve? What is its effect upon cushioning and upon exhaust?	120
158. What is "minus cover" or "minus lap" on the exhaust? What is its effect upon the exhaust and upon cushioning?	121

	PAGE
159. What is "cushioning" or "compression" in a steam cylinder? How is it affected by the amount of cover or of minus cover there may be upon the exhaust? How is it affected by the exhaust pressure? ...	122
160. What is "mean effective pressure"? How is its amount ascertained?	122
161. What is a dial vacuum gauge? What is its construction? For what is it used? About what amount should it show when the engine is working all right? What effect have the variations it indicates on the performance of the engine?	124
162. Does the vacuum gauge enable you to tell what pressure there is in the condenser, or must you have recourse also to the barometer to arrive at that? How would you ascertain the actual amount of back pressure there is in the condenser?	125
163. What is a barometer? What is its construction? Is a barometer sometimes used instead of a vacuum gauge? In what respect does the weather barometer differ from the vacuum gauge barometer? ...	125
164. The common vacuum gauge and the common steam gauge; in which of them are the graduations marked from atmospheric pressure? Does either of them tell what is the true actual pressure in the boiler or in the condenser?	126
165. Do steam and vacuum gauges vary with the variations of the weather barometer? When the weather barometer varies from 29 to 31 how much will the vacuum gauge vary and how will that affect the working of the engine? Why?	127
166. Vacuum is generally stated as so many inches. What is meant by, say, 20 inches vacuum? What does that tell us about the absolute pressure of the vapour then in the condenser?	128
167. From what depth will a pump draw water? Is there any limit? Why?	128
168. What is vacuum? Can vacuum move a piston? When the temperature of the water in the condenser is 212° Fahrenheit, what is the greatest degree of vacuum there can then be in the condenser?	129
169. What is a thermometer? What is its construction? What is the property of matter that is the principle of its construction? What temperatures are regularly noted by careful engineers?	129
170. What is the temperature of (1) melting ice, (2) boiling water, (3) steam about 60 lbs. pressure by the steam gauge, (4) steam about 100 lbs., (5) steam about 150 lbs., (6) smoke in the funnel, (7) water in the hot well?	131
171. What is meant by the "conduction" of heat? Give examples of it in the boiler and in the engine.	131
172. What is meant by the "convection" of heat? Give examples of it in the boiler and in the engine.	132
173. What is meant by "radiation" of heat? Give examples of it in the boiler and in the engine.	132

CONTENTS

xix

PAGE

174. Which is convection, which is radiation, and which is conduction in the following cases :—(1) Heat from the glowing fuel to the furnace crown? (2) Heat passing from one side of the furnace crown plate to the other? (3) Heat passing from the steam pipes in the engine room? (4) The heat of evaporation?	132
175. What are the effective heating surfaces of a marine boiler?	133
176. What parts of a marine engine are exposed to danger when the temperature is below freezing point?	133
177. What precautions are necessary in cold climates when the temperature is below freezing point?	134
178. State as many ways as you can by which a boiler might not get its full feed. A boiler, or one of a set of boilers, gets short of water although the feed valve is open its proper amount; to what causes might this be due?	134
179. Of what are furnace bars generally made? About what thickness are they at the top? About what space is between them? Are the bars put further apart for Newcastle than for Welsh coal?	134
180. Which burns faster, Newcastle coal or Welsh coal? Which is the flaming coal? Which makes more smoke?	135
181. About how many tons of steam coal will be burnt per day in four furnaces, each 3' 0" wide, and of about the usual length? On what grounds do you say so?	135
182. About how many tons of steam coal will be burnt per day with good triple expansion engines to drive an ordinary steamer of 40 feet beam 10 knots an hour by steam alone? On what grounds do you say so? What percentage more coal would be required to propel the same steamer 1 knot faster?	137
183. About how many tons of steam coal will be burnt per day with a good triple expansion engine, surface condensers, the low pressure cylinder 60 inches diameter, doing average work? On what grounds do you say so?	138
184. A pair of inverted cylinder direct acting engines, there is a liner half an inch thick between the ahead eccentric rod and the eccentric strap, in overhauling the engine this piece is lost and forgotten; what difference will its omission make in the working of the engine, on the admission, on the cut off, and on the exhaust of the steam? Which will take place earlier and which later, distinguishing between the up stroke and the down stroke?	138
185. In a pair of inverted cylinder direct acting engines driving a right-hand screw, on which of the crosshead guide bars is the pressure greatest in the up stroke, and on which in the down stroke?	140
186. A screw propeller is getting loose, it has a little play on the shaft, sideways on the key or feather; how will this show in the engine room?	140

	PAGE
187. How would you prove whether the centre line of the trunnions of an oscillating cylinder be fair with the centre line of the main shaft? ...	140
188. How can the fairness of a line of screw shafting be tested without lifting the shafts?	140
189. Where are steel forgings generally used in marine engines?	141
190. What is the composition of nickel steel? Where is it sometimes used in engines and boilers?	141
191. How is forced draught generated on board ship and supplied to boiler furnaces? Is the air heated before delivery? If so, how? ...	141
192. What is "induced" draught? Compare the merits of "forced" and of "induced" draughts.	142
193. How is the intensity of forced or induced draught measured? What is the usual pressure employed in the Mercantile Marine?	145
194. An explosive gas is liberated from bunker coal. Usually in well ventilated bunkers this gas escapes into the atmosphere without doing harm. In ill-ventilated bunkers the gas, after mixing with a certain proportion of common air, has been known to explode when a naked light has been brought into contact with it. What is the composition of the gas? Where is it found, in bunkers, 'tween decks, pockets, and coal shoots? How may it be got rid of as soon as it evolves from the coal? How many cubic feet of air to one of the gas forms a violent explosive mixture?	147
195. A lighted lamp or candle has sometimes been lowered into an apparently empty paraffin tank and produced an explosion resulting in injury to the person holding the light. What did the tank probably contain, and what produced the explosion?	147
196. In vessels carrying coal cargoes it has been observed that, generally speaking, the gas which escapes from the body of the coal is found more abundantly at the forward end of the hold than at the after end. Why should this be so?	148
197. In recently opened ballast tanks, double-bottoms, and boilers, a light lowered into either has sometimes been extinguished. What would in all probability cause this?	148
198. In double-bottom steamers where does the bilge water lie, and where are the roses of the bilge pipes fitted?	149
199. What is the advantage of a large rose over a small one?	149
200. Why, especially in vessels carrying cargoes liable to shift, should engine bilge suction be fitted to both wings of the bilge?	150
201. In a heavily listed vessel, why is it difficult to keep steam?	150
202. If the engine bilge pumps get choked and water accumulates in the stokehold bilges, what effect does the water have upon the bilge boards and stokehold plates when the ship is rolling violently? ...	151

CONTENTS

xxi

PAGE

203. In a triple-expansion engine, what spare gear do you consider necessary in the case of a foreign-going ship? Also what stores would you provide for a voyage to New Zealand?	151
204. What means are sometimes provided for temporarily coupling together the broken parts of, say, a tunnel shaft? Describe the fitting. ...	153
205. Does the pressure on the thrust collars vary with the horse power, or with the speed of the ship, or how?	154
206. If the holding-down bolts of a thrust-bearing should become slack, what effect would it have upon the working of the engines?	155
207. In an engine with three cranks, which of the three is subject to the greatest torsional stress (1) in going ahead, (2) in going astern? ...	155
208. Is it usual to make the crank shaft of a triple or quadruple expansion engine in one piece? And is the diameter of the shaft uniform from end to end? Give your reasons for the practice which obtains. ...	155
209. In a "built" crank shaft how are the webs rigidly secured to the pins and to the body of shaft?	156
210. There are various descriptions of donkey engines in use on board ship for pumping purposes. Some pumps are fitted with escape valves, some are not. Why should this be?	157
211. Explain the function of an air vessel fitted to a feed pump. Make rough hand sketches of (1) a satisfactory vessel, (2) an unsatisfactory vessel, where, say, the air spring has been destroyed by carelessness, or has never been properly provided.	158
212. Should cocks or escape valves be fitted to air vessels? Why, or why not?	159
213. Where, by preference, should the escape valve of a feed pump be placed? Why?	160
214. Scum cocks are sometimes fitted to boiler shells at a height convenient for engineers to manipulate when standing in the stokehold; the scum pipes in such cases are led upward, inside the boiler, to a little above the combustion chamber tops. What danger may arise from this arrangement?	160
215. Cocks for testing the water level of boilers are sometimes fitted within reach of the engineer who is standing in the stokehold. These may have internal pipes leading upward and terminating at various levels. Under what circumstances may these become misleading? ...	160
216. Why should the pipe which leads from the bottom of the water-gauge column to the bottom of the boiler front, or back, be covered with non-conducting material? Why also should it never have lengthy horizontal bends?	161
217. In your own experience, how frequently is this pipe removed and cleared?	161
218. Why, even with the best of water-gauges, is it advisable occasionally to use the drain-cock?	161

	PAGE
219. Steam loops have sometimes been inadvertently made in the length of piping leading from the top of the water-gauge column to the top of the boiler. Roughly sketch such a loop and explain the danger arising from its existence.	162
220. Describe your method of thoroughly testing the water-gauge system to satisfy yourself that all the cocks and pipes are clear. Your answer can be written on a supplementary sheet of foolscap, which the Examiner will hand you. Hand sketches, mere lines indicating pipes, and circles indicating cocks should be made. Identify the cocks and pipes by letters or numerals.	163
221. Describe the construction of a water-tube boiler, mentioning the type selected.	166
222. In a water-tube boiler, how is an economiser fitted, and what is its duty?	166
223. How is the water-gauge fitted in a water-tube boiler? Are glass gauges used?	168
224. The pressure of the steam in water-tube boilers is sometimes greater than at the engines. Why is this, and what percentage above the engine pressure does it amount to? How is this difference of pressure maintained?	168
225. Describe any automatic method of feeding water-tube boilers. Of what material are the tubes made?	172
226. Describe the construction of any steam turbine you are acquainted with, which is used on board ship. How is the expansion of steam effected? How many propeller shafts are employed, and how many propellers?	174
227. Is the same power in a steam turbine available to go astern as to go ahead?	179
228. Of what material are the propellers made in a steam turbine?	179
229. How many pounds of coal per indicated horse-power per hour are burnt with turbine engines? Name the type of boiler in use.	179
230. Describe one of the several classes of refrigerating machinery in use on board ship. Several types exist, one being more economical than the rest. Which is it?	180
231. Describe the defects to which the selected type is subject. How are the defects overcome?	181
232. How frequently are the parts opened out for examination? Name the parts.	181
233. How frequently are the condensers of refrigerating plants opened for examination? How frequently are the coils tested by hydraulic pressure? On which side of the coil is corrosion most commonly found? Why should this be so?	182
234. Where ammonia is used in refrigerating machinery, should the machinery by preference be isolated? Why? In reply give what information you possess bearing on the matter, naming the ships for purposes of identification.	182

CONTENTS

xxiii

	PAGE
235. Explain how the ammonia is removed from the tubes in which it is supplied, and how passed into the refrigerating machine. ...	183
236. What objection is there to the presence of water in the ammonia? ...	184
237. Describe the ammonia process of refrigeration. ...	184
238. Of what material are the parts made which are in contact with the ammonia? ...	184
239. Are escape valves fitted to the compressors of ammonia machines? ...	186
240. What is the maximum pressure found in the compressors of ammonia machines? ...	186
241. What kind of pressure and other gauges are used in ammonia machines? ...	186
242. Explain how carbonic acid is removed from the tubes in which it is supplied, and how passed into the refrigerating machine. ...	188
243. What objection is there to the presence of water in the carbonic acid? ...	188
244. Describe the carbonic acid process of refrigeration. ...	188
245. Of what material are the parts made which are in contact with the carbonic acid? ...	189
246. Are escape valves fitted to the compressors of carbonic acid machines? ...	189
247. What is the maximum pressure found in the compressors of carbonic acid machines? ...	189
248. What kind of pressure and other gauges are used in carbonic acid machines? ...	190
249. In which type of machine is brine used? What is its density? Where does it circulate? ...	190
250. Are fans for circulating air used in any of the refrigerating processes? If so, why are they necessary? ...	191
251. What means are in some cases employed for ascertaining the temperatures of refrigerating chambers without entering them? ...	191
252. What effect may the swabbing of the compressor piston rods have upon the working of refrigerating machinery? ...	192
253. What is a rectifier? Explain its use. ...	193
254. Describe the cold air process of refrigeration. ...	193
255. Of what material are the air suction and delivery valves of a cold air machine made? How are the valves kept on their seats? ...	194
256. How many compressors are there to a cold air machine? ...	194
257. What is the duty of the expansion cylinder of a cold air machine? ...	194
258. What objection is there to the presence of moisture in the air passed through the cold air machine? ...	195
259. How is water to some extent removed from the air? What is the minimum temperature of the air? ...	195

	PAGE
260. What is the maximum pressure found in the compressors of cold-air machines?	195
261. What kind of pressure and other gauges are used in cold air machines? ...	195
262. In refrigerating engines generally, where is the exhaust steam led? ...	195
263. Cold air chambers on board ship are insulated. How, and why? ...	196
264. Is it prudent to allow the wires of an electric circuit to pass through the insulation? Explain fully.	197
265. Describe the construction of a feed water heater and give the name of its manufacturer.	197
266. To about what temperature is the feed water raised by passing through a feed heater?	200
267. What fittings are usually placed on a feed heater? Why are they necessary?	200
268. Describe any well-known ash ejector.	201
269. Describe any well-known independent feed pumps.	203
270. Are independent feed pumps automatic in their action? Explain the action.	204
271. What advantage, if any, have independent feed pumps over feed pumps worked by the main engines?	204
272. Describe the construction of a feed filter, enumerating its valves and cocks.	205
273. How can the filter be cleaned? What ingredients are generally removed when cleaning takes place?	206
274. What is the intercepting material in a filter made of? How is it fitted? ...	207
275. Describe an evaporator, and mention the type.	207
276. What fittings are necessary with evaporators?	210
277. How is the brine got rid of in an evaporator?	210
278. How may the evaporator coils be cleaned?	211
279. What is a dynamo? Describe its various parts. For what is it used? ...	211
280. In what respect does an electric motor differ from a dynamo? Where are electric motors sometimes used on board ship?	215
281. Describe a system of electric lighting employed on board ship. ...	215
282. How is the position of a fault in the electric circuit discovered? ...	217
283. What is "sparking," and may it under some circumstances (naming them) be a danger?	220
284. What is "short circuiting," and to what evil may it give rise? ...	220
285. What means are employed to prevent any part of the circuit becoming overheated?	221
286. Describe the features of an arc lamp.	222

CONTENTS

XXV.

	PAGE
287. Describe the construction of a glow lamp.	222
288. What is the usual candle power of the small glow lamps in general use on board ship?	223
289. Define the following terms:—Ampere, volt, ohm, watt. What is the measure of an electrical horse power?	223
290. Explain the uses of switches, brushes, commutators, cut outs, field magnets, armatures and resistance coils.	223
291. Why is it desirable to fit a dynamo in a cool place on board ship? ...	227
292. What undesirable effect will ultimately occur to an electric wire, whose sectional area is constantly diminishing, say, through corrosion? ...	227
293. What danger might arise from leading electric wires through coal bunkers? ...	228
294. Is it better to lead electric wires above or below side scuttles? Why? ...	228
295. What instruments are used on board ship to ascertain the strength of an electric current?	228
296. Many ocean-going steamers are fitted with hydraulic cranes, etc. Where do they obtain their power? How is the hydraulic pressure kept at a relatively constant amount?	228
297. Is any difficulty experienced in working hydraulic cranes in frosty weather? If so, why?	231
298. Describe any steam steering gear you are acquainted with.	231
299. When the helm is put hard over and the ship is going full speed ahead, what prevents the rudder returning to the amidship position? ...	232
300. In the case of a steamship under way does the officer or man manipulating the steam steering wheel overcome any resistance exerted by the rudder?	232
301. Explain clearly what is being done by a helmsman manipulating the wheel of a steam steering engine.	233
302. Is there any difference between the amount of horse-power required to put a helm hard over, in a given time, when the vessel is going full speed ahead, and when she is going full speed astern? This question refers to the case of a steamer fitted with one rudder only, and demands a more complete answer than merely "yes" or "no." ...	233
303. What precautions should be taken before removing a manhole door of a steam boiler? In the absence of such precautions what casualties might occur?	234
304. Describe the chief features of the engine governor fitted to a steamer you have served in. Describe its action. Give the maker's name, and name of ship.	234
NOTE:— <i>The following six questions refer to oil motors, fitted to launches which carry passengers:—</i>	
305. Name the principal parts of an oil motor, and briefly state their functions. Give the name of the makers of the motor.	237

	PAGE
306. What kind of oil is usually employed in oil motors? What is its flash point? What is its specific gravity? What is its calorific power? What precautions are taken in its storage to guard the public against casualty by fire or explosion?	242
307. How many cylinders are generally used in oil motors? What kind of pistons are fitted? How frequently (measured in revolution) is explosion per cylinder effected? How is explosion in the cylinder carried out?	243
308. Describe how an oil motor is started. If starting prove difficult where would you chiefly look for defects? How is piston speed modified? How is the speed of vessel varied? How is reversing effected? ...	246
309. Before examining an oil motor with a naked light, what steps should be taken for safety's sake?	250
310. How frequently should an oil motor, working 12 hours a day, be opened up for examination, cleaned, and its parts readjusted? What difficulty arises when the internal parts become foul with carbonised oil? ...	250

Individual Questions dealing with Certain Particular Subjects are given in the Following Groups of Numbers.

	NUMBERS
ASH EJECTORS	268
AIR PUMPS	66, 67, 68, 69, 71, 72, 85, 86, 88
BAROMETER, THERMOMETER	163, 169
BLOW DOWN	35, 36, 277
BOILER CONSTRUCTION, STAYS, ETC.	17, 18, 19, 20, 21, 22, 24, 25, 25, 27, 30, 115, 137, 138, 142, 221, 222, 225
BOILER WORKING, ETC., ...	23, 25, 26, 29, 31, 32, 33, 34, 35, 37, 46, 47, 50, 51, 52, 53, 93, 123, 140, 141, 142, 178, 201, 224, 225
BREAKDOWNS, ETC.	23, 25, 26, 51, 178, 186, 204
CONDENSERS, ETC. 64, 71, 73, 74, 75, 76, 78, 79, 88, 121, 122, 134, 135, 136, 166	
DRAUGHT AND CONSUMPTION	32, 33, 34, 52, 53, 133, 134, 139, 179, 180, 181, 182, 183, 191, 192, 193
ELECTRICITY	279 to 295
ENGINES AND ENGINE DETAILS 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 82, 83, 84, 87, 92, 94, 95, 96, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 117, 118, 119, 120, 121, 124, 125, 126, 127, 128, 129, 130, 131, 132, 137, 149, 184, 185, 186, 187, 188, 198, 199, 200, 202, 205, 206, 207, 208, 209, 211	
EVAPORATORS	275, 276, 277, 278
FEED HEATERS AND FILTERS	222, 265, 266, 267, 272, 273, 274
FREEZING	176, 177
GASES, ETC.	194, 195, 196, 197

CONTENTS

xxvii

	NUMBERS
GAUGES 41, 42, 43, 44, 45, 161, 164, 165, 218, 219, 220, 223, 241, 248, 261, 295	
GOVERNORS 70, 304	
HEAT, ETC. 171, 172, 173, 174, 175	
HYDRAULICS 296, 297	
MEAN EFFECTIVE PRESSURE, ETC. 148, 150, 151, 160	
OIL MOTORS 305 to 310	
PROPELLERS AND PADDLE WHEELS ... 89, 90, 91, 97, 98, 99, 100, 101, 102, 103, 104, 132	
POWER 146, 147	
PUMPS 64, 65, 66, 67, 68, 69, 71, 76, 81, 167, 269, 270, 271	
REFRIGERATING MACHINERY—	
General ... 230, 231, 232, 233, 249, 250, 251, 252, 253, 262, 263, 264	
Ammonia 234, 235, 236, 237, 238, 239, 240, 241, 253	
Carbonic acid gas 242, 243, 244, 245, 246, 247, 248	
Cold air 252, 254, 255, 256, 257, 258, 259, 260, 261	
SAFETY VALVES 38, 39, 40, 239, 246	
SALTING AND SCALING, ETC. 46, 47, 48, 49, 93	
STRENGTH, ETC., OF MATERIALS 5, 6, 7, 8, 9, 14, 189, 190	
STORES 203	
STEERING GEAR, ETC. 298, 299, 300, 301, 302	
STRESS AND EXPANSION BY HEAT 10, 11, 16, 21	
SLIDE VALVES AND SETTING 59, 60, 152, 153, 154, 155, 156, 157, 158, 159, 184	
SUPERHEATER 28	
TEMPERING, WELDING, CASE HARDENING 12, 13, 14, 15	
TURBINES 226, 227, 228, 229	
TEMPERATURES 73, 169, 170	
VACUUM 162, 166, 168, 303	
VALVES AND COCKS 35, 36, 37, 38, 39, 40, 42, 44, 47, 55, 56, 59, 60, 63, 65, 69, 72, 77, 79, 80, 92, 95, 113, 114, 116, 121, 122, 123, 143, 144, 145, 210, 212, 213, 214, 215, 224, 239, 246	
WATER-GAUGE AND ITS WORKING 37, 41, 42, 215, 216, 217, 218, 219, 220, 223	
WATER-TUBE BOILERS 221, 222, 223, 224, 225	
WHERE CERTAIN MATERIALS ARE USED ...1, 2, 3, 4, 5, 6, 189, 238, 245, 255	

Nos. of Questions to which Alternative Settings are given.

7, 8, 9, 16, 17, 18, 23, 25, 28, 31, 32, 33, 37, 38, 39, 42, 45, 47, 48, 49, 54, 57, 58, 60, 61, 64, 68, 73, 75, 76, 78, 79, 81, 83, 84, 90, 93, 96, 97, 99, 100, 103, 105, 108, 109, 112, 117, 119, 125, 126, 129, 133, 134, 136, 139, 140, 141, 143, 145, 146, 150, 152, 153, 155, 157, 158, 159, 160, 164, 167, 168, 175, 176, 179, 181, 186, 189, 193, 195, 201, 205, 206, 208, 210, 211, 212, 215, 218, 219, 222, 224, 225, 226, 230, 234, 238, 247, 249, 250, 257, 262, 263, 266, 268, 271, 272, 277, 280, 282, 283, 284, 291, 292, 293, 297, 300, 303, 306, 307, 309, 310.

FIGURE INDEX

Fig.	Page
1. Beam bending ...	5
2. Main boiler, section of ...	8
3. Caulking ...	10
4. Boiler stay ends ...	11
5. Screwed stays, etc., ...	12
6. Stay tubes ...	13
7. Cracked tube plate ...	15
8. Wet and dry uptakes ...	16
9. Superheater ...	19
10. Priming ...	20
11. Spanner guard ...	22
12. Cap of safety valve ...	24
13. Different types of lips for safety valves ...	26
14. Water-gauges (various arrangements) ...	27
15. Face of pressure gauge ...	28
16. Mechanism „ „ ...	28
17. Drain cock, etc., pressure gauge ...	29
18. Scum cock ...	31
19. Salinometer ...	34
20. Patent tube stopper ...	35
21. „ „ ...	36
22. Steam piston ...	37
23. Escape valve for cylinder ...	39
24. Styles of compound engines ...	41
25. Expansion slide valve ...	43
26. Relief rings on slide valves ...	44
27. Loose eccentric and gab lever ...	46
28. Double beat valve ...	47
29. Weir's "Uniflux" condenser ...	49
30. Air pump bucket ...	50
31. "Bon-Accord" pump ...	52
32. Edward's air pump ...	54
33. Governor details ...	56
34. „ „ ...	57
35. „ „ ...	58
36. Bilge injection, jet condenser ...	61
37. „ „ surface „ ...	62

xxix

FIG.		PAGE
38.	Securing condenser tube ends	64
39.	Interceptor	67
40.	Finding pitch of propeller	70
41.	Right and left hand propeller	71
42.	Steam lubricator	75
43.	Radial floats	76
44.	Outer bearing for paddle shaft	79
45.	Clutch for "disconnecting"	80
46.	Expansion joint	82
47.	" box	82
48.	Trunnion bearing	84
49.	Thrust block	86
50.	Tail end shaft, liners on	87
51.	" " and stern tube	88
52.	Lignum vitæ bearing	90
53.	Steam jackets and cylinder liners	93
54.	Balance piston	94
55.	Air vessels	98
56.	Mud box	99
57.	Trunk engine	100
58.	Hydrokineter	107
59.	Haystack boiler	109
60.	Feed escape valve	110
61.	Side discharge valve	111
62.	Unadjustable check valve	112
63.	Piston slide valve	116
64.	Port open for "lead"	118
65.	Showing steam lap	119
66.	" " "	120
67.	Exhaust lap	120
68.	Exhaust lead or minus lap	121
69.	Indicator card divided up for mean effective pressure measurement	123
70.	Barometer	126
71.	Thermometers	130
72.	Pressure on guide bar	139
73.	Induced draught	142
74.	Balanced " "	143
75.	U gauge for draught	146
76.	Roses on bilge pipes	149
77.	Effect on water level in boilers of listed vessel	150
78.	Shaft couplings	154
79.	Securing pin and shaft to crank web	157
80.	Air vessels	158
81.	Loop or trap in steam pipe to water-gauge	162
82.	Water-gauge diagram	164
83.	Babcock & Wilcox water-tube boiler	165
84.	" " " "	167
85.	Auld's reducing valve	170
86.	" " "	171

FIG.		PAGE
87.	Auld's reducing valve	172
88.	Babcock & Wilcox boiler feed regulator	173
89.	Path of steam in turbine	174
90.	Turbine blading	175
91.	Dummy strips for turbine	176
92.	Geared turbine	177
93.	Diagram of freezer	180
94.	Hall's vertical single marine type CO ₂ machine	183
95.	„ horizontal duplex CO ₂ machine	185
96.	„ „ CO ₂ machine electrically driven	187
97.	„ escape valve	189
98.	Hold insulation	196
99.	Weir's "injection" feed heater	198
100.	„ multiflow feed heater	199
100a.	„ surface contact feed heater	199
101.	Position and arrangement of feed heater	Plate IX.
102.	„ „ „	„
103.	„ „ „	„
104.	See's ash ejector	202
105.	Weir's feed pump	203
106.	Feed filter	205
107.	Weir's evaporator	208
108.	„	209
109.	Diagram of dynamo	212
110.	„ shunt winding	213
111.	„ series winding	213
112.	„ compound winding	214
113.	Series and parallel wiring	215
114.	Parallel series wiring	216
115.	Diagram of fuse board	216
116.	„ single wire and the two wire systems of ship wiring	217
117.	Detector or galvanometer	218
118.	Tests for faults on circuits	219
119.	Fuses	221
120.	Switches	224
121.	Resistance coils	226
122.	Ammeter and voltmeter	229
123.	Diagram of hydraulic accumulator	230
124.	Alley & McLellan's steering gear	Plate XIV.
125.	„ „ „	„
126.	Aspinall's governor	235
127.	„ „	236
128.	„ „	236
129.	Parsons marine motor	237
130.	„ „	238
131.	„ „	239
132.	Silencer	240
133.	Diagram of strokes, oil motor	241
134.	Jump spark system of ignition	244

FIGURE INDEX							xxxi
FIG.							PAGE
135.	Diagram of magneto ignition	...	...	...	...	...	245
136.	Clutch	...	...	...	...	...	247
137.	Reversing gear	...	...	...	...	...	248
138.	"	...	...	...	...	...	249

LIST OF PLATES							TO FACE PAGE
I.	Link motion	...	...	...	...	...	42
II.	Feathering paddle wheel	...	...	...	...	...	78
III.	Oscillating engine valve gear	...	...	...	...	...	102
IV.	Meyer-Smith oil burning installation	...	...	...	...	...	136
V.	Howden's forced draught	...	...	...	...	...	142
VI.	H.P. turbine	...	...	...	...	...	178
VII.	L.P. and reverse turbines	...	...	...	...	...	178
VIII.	Twin screw installation of geared turbines	...	...	...	...	...	179
IX.	Positions of Weir's feed heaters	...	...	...	...	...	200
X.	Weir's evaporator ordinary type	...	...	...	...	...	210
XI.	" lunette type	...	...	...	...	...	210
XII.	Holmes' dynamo and high speed engine	...	...	...	...	...	211
XIII.	Wiring plan of ship electric instalation	...	...	...	...	...	217
XIV.	Alley & McLellan's steam steering gear	...	...	...	...	...	232
XV.	"Djinn" marine oil engines	...	...	...	...	...	242

Elementary Questions and Answers.

1. What parts of an engine are generally made of wrought iron?

Ans.—All such parts as piston rod with crosshead and connecting rods, crank, thrust, tunnel and tail end shafts, eccentric rods, straps, reversing link, drag links, weigh bar shaft, valve spindles, coupling bolts, crosshead and bottom end bolts, also the main bearing bolts, air pump levers and the pump crosshead, spears for feed and bilge pump rams, air pump rod, pump and crosshead links (excluding their brasses), and propeller nut can be made of wrought iron, but many of these are now made of mild steel.

2. What parts of an engine are generally made of cast iron?

Ans.—The cylinders and cylinder liners, slide valves and valve chests (steam chests), bedplate, columns, condenser, thrust block seating, plummer blocks, pump chambers and covers, stop and throttle valve chests, injection and discharge valve chests and the main donkey suction valve box, air vessel, hot well, piston and slide valve packing rings, thrust shoes, propeller, crosshead shoes, and in short any parts subject to compression, as cast iron is very strong when subject to compressive stress.

3. For what parts of an engine is steel sometimes used?

Ans.—Mild steel forged is used for piston rods, crossheads, connecting rods, eccentric rods, valve spindles, crank, thrust and tunnel shafts, air pump levers and pump crosshead, and nowadays most parts which formerly were of wrought iron are of steel. Cast steel is used for eccentric straps, reversing arms, eccentric rod forked ends (excluding their brasses), stop valve chests.

Hard steel, or steel capable of taking a temper is used for safety and escape valve springs, coach springs for piston-packing rings.

4. What parts of an engine are generally made of brass or gun-metal?

Ans.—Brass or gun-metal is used for air pump link brasses, air pump bucket, "Kinghorn" valves for air pump, stern tube bush, propellers, sometimes main bearings, top end brass of connecting rod, slide valve spindle tumbling block, liners on the tail end shaft. The various steam and water cocks upon the boilers and all such valves and cocks as escape valve, drain cocks, throttle valve, stop valve, are made of brass or gun-metal, including their seats, neck bushes for glands and stuffing boxes.

5. Where is white metal sometimes used? On account of what property possessed by it is it adopted? What objection is there to its more general use?

Ans.—Main and tunnel bearings now are usually of cast iron with "white metal" run into them to form the bearing surfaces. Guide shoes have strips of white metal fitted to them, as also eccentric straps and thrust shoes. Some stern tubes have white metal bushes fitted and then *no* liners are required on the tail end shaft.

It is adopted because the friction between it and the cast or wrought iron or steel is very much *less* than with ordinary brass. This can be understood from the greasy feel white metal has to the touch.

The objection to its use is that owing to the melting point being low (about 600° F.) if the bearing, etc., accidentally becomes very hot, this temperature is passed and the metal runs out. Another point is that if the metal be run into the bearing at too great a temperature it will most likely be "burnt" and may, at any future time, powder out like sand. When either of these accidents happen the shaft, etc., is almost certain to become grooved or scored.

6. For what parts is muntz metal sometimes used? Is it malleable? For what properties is it valued?

Ans.—Muntz metal is used principally for condenser tube plates, tubes, air and circulating pump rods. Feed and bilge rams, if not of bronze, are sometimes of muntz metal, and bolts or studs always under water are best made of this material. It is malleable and lends itself to being forged hot. Like brass, it is not liable to corrosion, and can be made to have a high tensile strength of at least 22 tons per square inch.

7. What difference is there in the composition of cast iron, of wrought iron, and of steel?

Ans.—All three come originally from iron ore being smelted, and it is in the after treatment of the crude metal that the particular material is produced. Thus cast iron is the crude pig iron from the blast furnace, remelted in the cupola furnace, together with clean scrap cast iron, and the molten metal run into moulds to form cylinders, etc. It contains from 2 to 5 per cent. of carbon, a very large amount of which is in a free state amongst the iron.

Wrought iron is a mass of the crude metal worked on the puddling hearth to abstract practically all the carbon, leaving an almost pure iron having a carbon percentage of only about '015.

Steel may be of two qualities, "mild" or "hard," and in either case consists of the iron being sent through a process whereby its carbon is eliminated, and *then* a definite small percentage of this is added, the whole mixed together and run into ingot moulds, whence the plates, bars, etc., are rolled out. If the steel has a percentage of from '1 to '3 of carbon, that is mild steel. Hard or tempering steel contains from about '7 per cent. to 1'6 per cent. of carbon, and in *all* classes of steel the most of the carbon is *combined* with the iron, not in the free state. What is called a high carbon steel contains about '4 per cent. of carbon.

7. ALTERNATIVE SETTING. — What difference exists between zinc, brass, and silver?

Ans.—Zinc and silver are "elements," which means that no other metal is mixed with them, but brass is an *alloy*, being composed of copper and zinc, and thus is a mixture of two elements. Alloys may consist of any number of metals from two up.

8. How can cast iron, wrought iron, and steel be distinguished from each other?

Ans.—By the nature of the fracture when a piece is broken (not cut). Cast iron shows a crystalline fracture, and ranges from a deep black grey to a light grey, and dirties the fingers on touching it. It is very brittle and breaks off sharp, ductility being absent; very low tensile strength. Wrought iron shows on fracture a very fibrous formation, is tough, has great ductility, but will not temper, has good tensile strength, and may be forged and welded, and does not dirty the fingers. Mild steel shows a light grey fracture, fibrous if it has been

much rolled, but usually a fine crystalline appearance is shown. It is very ductile, tough, and of greater strength than wrought iron, but will not temper, though it may be forged and welded. Hard steel shows a light silver grey and at times almost a pink fracture, is hard, has very little ductility, high tensile strength, and will take a temper, and will forge to a slight extent, but should not be welded. Neither mild nor hard steel dirty the fingers.

8. ALTERNATIVE SETTING.—State how an alloy can be distinguished from an elemental substance.

Ans.—To ascertain whether a substance is an alloy or not it must be “analysed” by means of certain physical and chemical treatment and “reactions,” by which can be proved the presence or otherwise of certain metals. An alloy containing copper turns green when ammonia is brought into contact with it. Colour of fracture is also a guide, but not a sure one.

9. What are the different properties of cast iron, of wrought iron, and of steel?

Ans.—Cast iron is very fluid at high temperatures, and runs well into moulds, making “castings.” It will not forge or temper. Is strongest in compression, but very weak in tension. The lighter the grey of the iron the harder and better the quality, as less carbon is in a “free” state, the greater portion being combined with the iron.

Wrought iron will not run into moulds, but it forges very readily and can be welded. Stronger in tension than in compression.

Steel can be cast, welded, and forged, or tempered according to the amount of carbon it contains. Is stronger, size for size, than wrought iron. Steel also takes a better finish than wrought or cast iron.

9. ALTERNATIVE SETTING.—If great strength is needed in pillars, struts, beams, and plates, state the materials you would use in each.

Ans.—Pillars and struts being in compression could be of cast iron, provided they are not exposed to lateral blows, as if so they must be of wrought iron or mild steel. Beams and plates must be of these latter materials as parts of them are exposed to tension.

10. What is meant by the terms "breaking stress," "proof stress," "safe working stress"?

Ans.—Breaking stress means the load, force, or weight, usually in tons per square inch section of the material, which will produce fracture either by tension or compression, or by both, as a beam being bent. (See figure 1.)

Proof stress is the force, etc., per unit of section which can be applied to a material an absolutely unlimited number of times *without* any permanent deformation occurring. In amount it varies between $\frac{1}{3}$ to $\frac{1}{2}$ of the breaking stress for the same material and section.

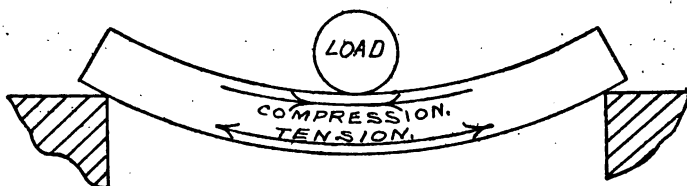


FIG. 1.

Safe working stress is the load, etc., per unit of section which it is considered "safe" to repeatedly apply, and in amount is usually taken at $\frac{1}{3}$ of the breaking stress of same material and section. The Board of Trade quote "factors of safety" ranging from 4.5 to 6, *i.e.*,

$$\frac{\text{breaking stress lbs. per square inch}}{4.5 \text{ to } 6} = \text{safe working stress.}$$

11. What is the cohesive strength or breaking stress of good ordinary wrought iron?

Ans.—In amount, really good wrought iron gives from about 24 tons to 27 tons per square inch of section. Average say, of 26 tons, but many samples of ordinary commercial wrought iron only give about 20 to 22 tons.

12. Tempering steel, how is it done, and in what order do the colours come?

Ans.—To temper say a chisel, heat the whole to a good red heat, *not* white hot, plunge the cutting end into cold water, or salt and water, and cool out about 1 inch length. Rub this part with an old file, to brighten and watch the colours appear, first very light straw, then

deeper straw, light greyish blue, and on to a very deep blue, which latter gives the softest temper. When the desired colour is reached, cool the *whole* tool right out in the cold water. As the act of plunging the end into cold water rendered that portion "glass" hard, the process of tempering, or allowing heat to travel down to this part, results in a definite softening to a slight extent of the brittle part.

Note.—The colours are caused by a film of oxidation forming by reason of the heat travelling down and the thicker the film the deeper the colour.

13. What is case hardening?

Ans.—It is the converting of the surface or skin of wrought iron into steel, by placing the article in a box and filling same with bones, scraps of leather, horn, etc., or anything which is rich in carbon. The whole is then placed in a furnace and raised to a good heat, being kept at that for some hours and then slung out and cooled in water. The carbon enters into the skin of the iron and converts that portion into steel. Another method is to use yellow prussiate of potash as follows:—Heat the articles to a good heat (blood red) and cover the surface with the yellow prussiate, following directly by cooling out in water.

14. Which of the common metals or alloys can be forged, and which of them are brittle or "short"?

Ans.—Wrought iron, mild steel, tool steel, and muntz metal, can all be forged, but cast iron and brass are brittle and "short" and cannot be forged, though rolled brass if heated and then cooled in water will become more ductile and stand a certain amount of working, but becomes hard again under such actions.

15. What is meant by "welding"? Which of the common metals can be welded?

Ans.—By welding is meant the joining together of two pieces of wrought iron or mild steel by heating the ends to a white heat using sand for a "flux," bringing them together on the anvil, then hammering the ends into one mass, with either hand, sledge, steam or pneumatic hammer, depending upon the size of the parts.

16. The expansion of metals by heat; give examples of this in the engine and in the boiler?

Ans.—All metals used for engines and boilers expand when heated, and common examples are the steam pipes lengthening when hot and to allow for this, large bends must be worked into them or the more common expansion joint fitted, either of the stuffing box form or the corrugated type. Cylinders expanding under heat of the steam. The top of the boiler expanding *more* than the bottom and pulling upon this latter. Furnaces expanding and fire bars also, which make it necessary to have an incline at front end (or dead plate) of their support for them to rise upon without displacing the back bridge. Corrugated and ribbed furnaces allow for the expansion very much better than plain ones

16. ALTERNATIVE SETTING.—Does every substance expand on heating? Give an everyday example.

Ans.—Water at a low temperature contracts by heating. For example, when at 39.1°F . it is in its smallest volume, and on cooling down to 32°F . it expands. Therefore if it be already at, say, 32° and we heat it to 39° it gets smaller.

17. In the construction of steel cylindrical marine boilers, for what parts have the plates to be worked hot? What precautionary treatment of these plates is afterwards necessary?

Ans.—Any plates requiring flanging like the end plates and the combustion chamber plates must be worked hot both for the actual flanging and for the subsequent welding up where the V shaped pieces were cut out. As this subsequent heating leaves a zone of the plate with very little strength (just where the heat passes off to the unheated part) the *whole* plate must be "annealed," to do which it is inserted in a special furnace and raised to a good red heat, kept at that for some hours, dependent on its thickness and then slung out and allowed to cool down gradually. The strength of the *whole* of it is then the same as before local heating. No operation about annealing should be hurried.

- 17. ALTERNATIVE SETTING.**—If boiler plates are not flanged by cutting and welding how is the flanging carried out?

Ans.—By hydraulic presses, using male and female dies which force the edge of plate to bend over and so form the flange.

- 17. ALTERNATIVE SETTING.**—If iron be used in place of steel for boiler plates what special treatment is necessary after they are worked hot?

Ans.—None, because iron is not affected by having some parts of it heated while the adjacent portions are cool.

- 18. In what parts of cylindrical marine boilers is the strongest riveting employed? In which of the shell seams is it most necessary?**

Ans.—The longitudinal seams of the main shell plating are the strongest, being treble riveted because the stress coming upon them is twice that upon the circumferential seams. These latter are only double riveted, as are the seams of combustion chambers.

- 18. ALTERNATIVE SETTING.**—Why should longitudinal seams in a boiler require greater strength than circumferential ones?

Ans.—Because, owing to the shape of the boiler, the stress per square inch upon the shell rings is double that which comes upon the ends.

- 19. What is "caulking" and how are seams prepared for caulking?**

Ans.—Caulking means closing the edges of plates which have been riveted together, in order to make them water and steam tight. The edges of the plates must be planed or milled true before the riveting and afterwards the caulking tool which is a chisel having an edge about $\frac{1}{4}$ inch thick is used with a 3 or 4-lb. hammer to force the edge of one plate *tightly* down into contact with the plate it is against, thus ensuring no leakage. Sometimes pneumatic (the often called "windy") caulking

chisels are used and these strike blows with much greater rapidity than can be done by hand.

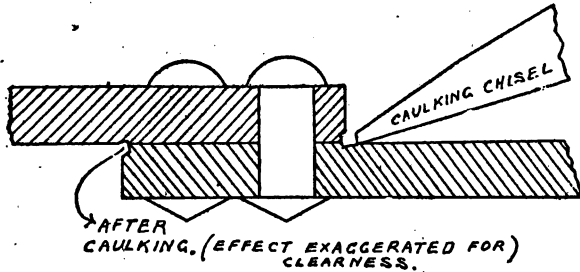


FIG. 3.

Note.—In the illustration the grooving effect on the plate is much magnified in order to show what the tool does. In practice there must be little or none of this grooving.

20. Describe the different ways of fastening the ends of the main stays of a boiler. What are the merits of, or objections to, the different plans?

Ans.—The best and most modern method is to swell the ends of the stay a little larger in diameter than the body portion, and cut screw threads on these ends. Pass the stays through clearance holes in the back and front end plates and secure by large nuts and washers inside and out (see fig. 4 *a*). The larger washers must be upon the *outside* of the end plates. In older boilers the stays were fixed either by having a T head formed at each end and secured by angle irons riveted to the plates (see fig. 4 *b*) or by forming a large single eye at each end of the stay and into both plates of the boiler securing strong double eyes and the connection between these and the stay was made by a pin whose shearing strength equalled, at least, the tensile strength of stay. This pin had a smaller split pin fitted through its end to prevent shaking out (see fig. 4 *c*). The merits and demerits may be expressed as follows:—Form “*a*,” is simple, fairly cheap to make and if of such a diameter as not to require spacing too near one another makes a good all round job, but does not allow very much room for a man to move about whilst inspecting the boiler. Form “*b*” is more costly to produce, and cannot be readily taken down if required. It allows though of being spaced further apart, as the angle iron supports the end plates and so more room is obtained for inspection purposes. Another

disadvantage of this type is that it cannot be made of steel owing to the heads having to be welded on. Form "c" is perhaps the best all round type if we do not mind some extra expense and also provided the cross

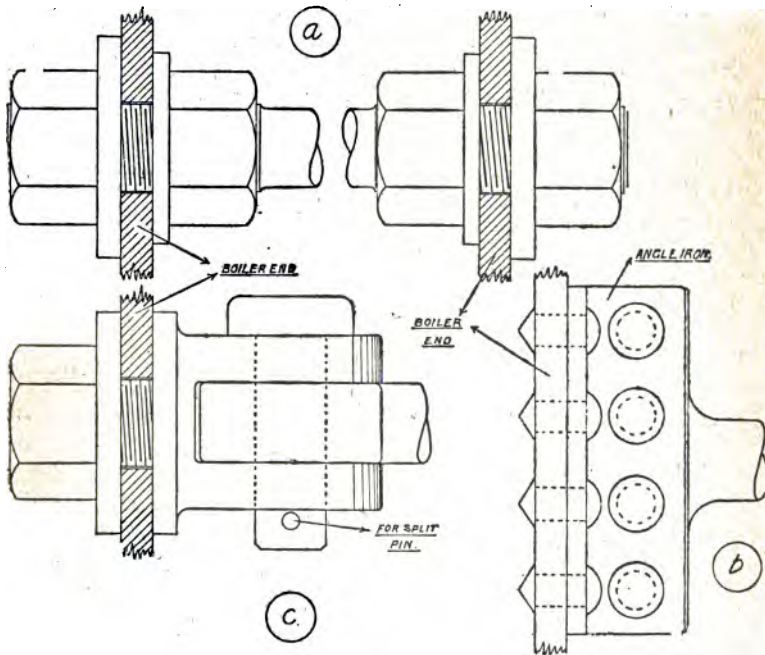


FIG. 4.

pin is of ample strength, otherwise it may bend or possibly shear right through, rendering the whole stay useless. It allows the stays to be readily removed to facilitate inspection. Taking *everything* into account though, the first type is the best and most common at the present day.

21. What stress per square inch is allowed on boiler stays?

Ans.—New solid wrought iron stays are allowed 7000 lbs. per square inch, but if welded 5000 lbs. New mild steel solid stays are allowed 9000 lbs. No welded steel stay is allowed.

22. Describe a riveted stay and state where such stays are commonly used.

Ans.—The true riveted stay has almost disappeared now, but it consisted of a plain length of stay bar cut a little longer than the outside distance of the plates it supported, was passed through holes drilled in both, and also a distance piece of tube *between* the plates (see fig. 5 *a*), the ends being well riveted over on to each plate, the distance piece preventing these crushing inwards. The better and more modern method is to drill the two holes and screw both with one

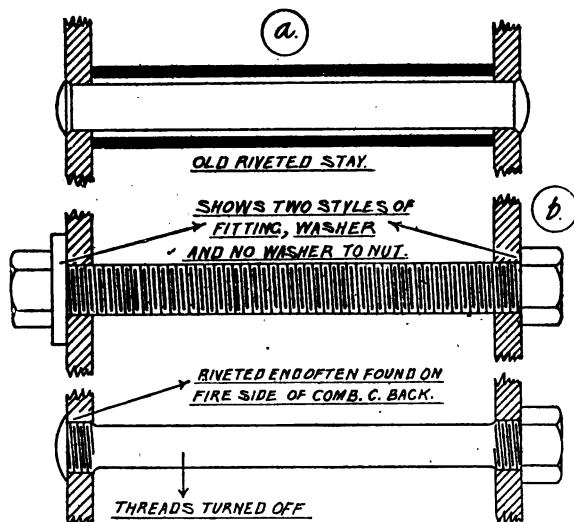


FIG. 5.

long tap, to ensure threads running on fair, one with the other. The stay is threaded its whole length and screwed through both holes, being held by nuts, and perhaps washers, at each end (see fig. 5 *b*).

Note.—Fig. 5 *c* shows an alternative style of screwed stay where the threads have been turned off to obtain a smooth surface and so lessen the deterioration of the stay. The riveted head may often be found with style *b* as well, at such places as the back of the combustion chamber just about where the flame impinges.

23. Where are thin places to be looked for in a boiler as it wears, and how is the thinness to be detected?

Ans.—The places mostly affected are shell-plate at water level, backs and bottoms of combustion chambers, furnace tubes on water side.

just above the line of fire bars, ashpits, top front plate of boiler if this forms the back of uptake, outside the boiler at the bottom on level of stokehold plates, and inside the boiler stool or cradle. Thinness can be detected either by eye, sounding by a medium weight hammer or best of all by drilling small holes through the suspected spots and afterwards plugging these up with fine threaded plugs.

23. ALTERNATIVE SETTING.—In surveying a boiler where would you look for defects due to action of ashes, abrasion by wash of the water, and excessive rusting?

Ans.—(This can be answered as well by what is already given.)

24. How are boiler tubes fixed? What are "stay tubes," and how are they secured?

Ans.—Ordinary or plain tubes are inserted through well-fitting holes in both tube plates until the combustion chamber end projects about $\frac{3}{16}$ inch, the front or smoke box end being then about $\frac{1}{2}$ inch through front tube plate. Both ends are then expanded and often the combustion chamber end is beaded over as well. The extra projection at the front allows the tube to be successively driven further through and the inner end rebeaded, etc., as the "back ends" wear away. Often

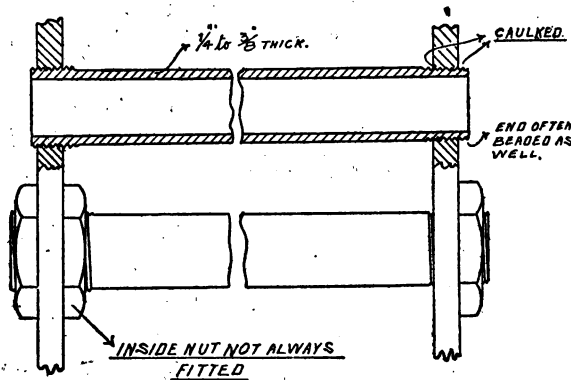


FIG. 6.

the front end of tube is swelled out about $\frac{1}{8}$ inch more in diameter than the combustion chamber end, as this facilitates passing the tubes through the plates. Stay tubes are made thicker than plain tubes owing to their acting as "stays" between the front and back tube plates,

and so having to withstand a greater stress. They are fine threaded each end and may be secured either by being screwed into the back tube plate and one nut fitted on the fire side of the plate, together with a nut inside and outside of the front tube plate, whose hole is now a clearance one, or by screwing both holes fine threaded with a specially long tap to go through both at once, *screwing* the tube into these two holes and fitting one nut on the outside at each end. With both styles the uptake end of tubes is slightly larger in diameter than the combustion chamber end to facilitate its passage through front tube plate.

Note.—The upper part of fig. 6 shows a style that is occasionally seen, but does not give such good results as the lower and more common method.

25. Where is it generally that boiler tubes leak? How is this defect repaired? What are the causes of this leaking?

Ans.—Tubes leak mostly at the combustion chamber or “back ends.” To remedy this, re-expand them, but if this does not effect a cure, drive the tube further through from the smoke box, cut off the bad end, and re-expand and bead over. If the tubes are old, it will be best to put in new ones when possible. The causes are scale accumulating round the necks on the water side, resulting in the tube ends and the immediate parts of the back tube plate getting over heated and then on the cooler air being admitted, through opening furnace doors, etc., a sudden contraction occurs which very soon breaks down the tightness of the original expanding, because the tube being thinner contracts *away* from the plate. Sometimes back ends will leak due to heavy vibrations set up when blowing boiler down.

25. ALTERNATIVE SETTINGS.—(1) If cold air is admitted to the furnaces leaks develop at the back ends. Why is this? (2) Heavy scale deposits on tubes and plates is apt to cause what trouble in a short time?

Ans.—(These can be answered from what is already given.)

26. What are the causes of cracked tube plates? Where are the cracks situated? How are they repaired?

Ans.—The causes are practically the same as for leaky back ends, viz.:—Scale accumulation causing overheating and subsequent admission

of cooler air, either by opening smoke box doors or the furnaces, whence the contraction cracks the plate (as well as causing tube ends to leak). Sometimes the cracks can be traced to improper annealing of the plate, if of mild steel. The cracks usually come between the holes for tubes and may be repaired by fitting what is called a "spectacle" patch. A piece of plate is cut to embrace the ends of two tubes between which the crack lies, then fastening this patch down with tap bolts (see fig. 7 a).

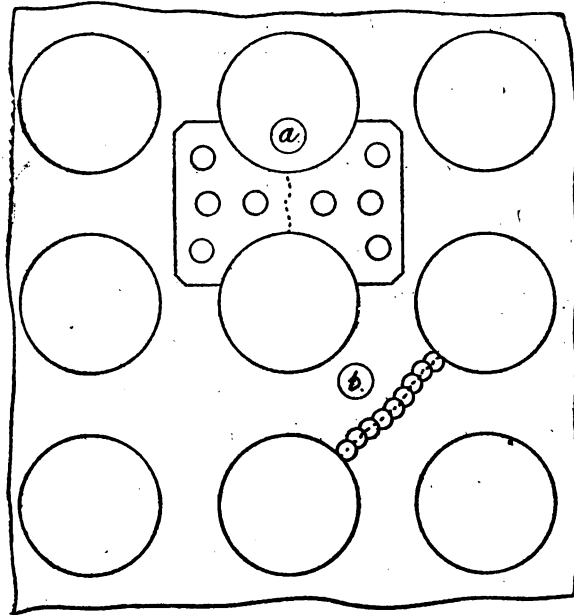


FIG. 7.

Another method is to take out the adjacent tubes, drill a hole about $\frac{3}{8}$ -inch diameter cutting just into the tube hole at each end, tap with fine thread and screw in a plug. Next drill another hole cutting into the plug a little and also removing some more of the cracked part, screw in another plug and proceed like this until the whole crack has been "lock plugged." If the first plugs are a trifle loose, a few blows from a hammer will rivet down their ends and make tight. File the outermost plugs to the curvature of the tube holes, insert tubes and re-expand.

27. What is the difference between a "dry uptake" and a "wet uptake?" Which requires more repair? Why? Where have you seen a wet uptake?

Ans.—A dry uptake is the usual form of smoke box and uptake met with on marine boilers, consisting of a light steel casing of thin plates and angle irons built up from the front of boiler, covering the tube ends and leading the waste gases up to the funnel. It is fitted with smoke box doors and baffles and is wholly outside the boiler. The

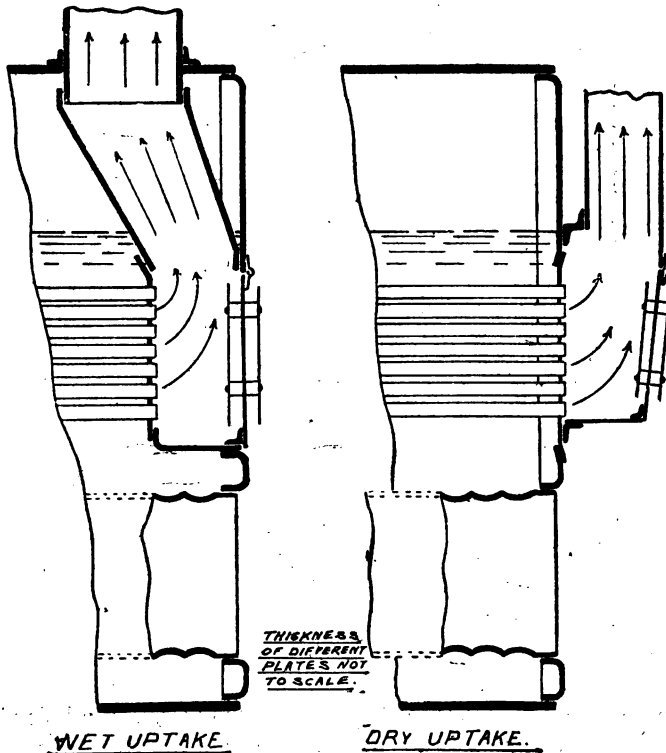


FIG. 8.

wet uptake, while sometimes met with in very old cylindrical boilers, is that usually found with common vertical donkey boilers and is a tube leading from the combustion chamber up through water and steam space of boiler, to the funnel. It is entirely inside the boiler and exposed to the full pressure, also, just about the water level very heavy rusting and

corrosion occurs, entailing much expense for repairs, besides the greater initial cost of construction. Wet uptakes are met with in haystack boilers, and the figure shows the two styles as appearing on cylindrical boilers.

28. What is a superheater? What is its construction? What valves are upon it? There is sometimes a gauge glass on it, what is that for? Are superheaters now in general use?

Ans.—A superheater is an arrangement for drying out of the steam the watery particles it contains as it comes direct from the boiler. One form consists of a series of wavy tubes arranged vertically in the uptake just above the level of the topmost row of smoke tubes. The top and bottom of the superheater consists of cast steel “headers” into which the wavy drying tubes are secured. Steam from the boiler enters at the top where the gases of combustion are the coolest, passes downwards and so meets hotter gases, finally issuing at the bottom header and away to the engines. The temperature of the steam can be brought up to 460° to 480° , and as its pressure is *not* raised by superheating, if it be, say, 160 lbs., temperature 371° F., there are $480^{\circ} - 371^{\circ} = 109^{\circ}$ of superheat.

Stop valves should be fitted to both entrance and exit, and the former should have a bye-pass valve with it, so that the superheater may be shut off when necessary and the steam sent round by the bye-pass pipe. A safety valve must be fitted, and a gauge glass also to show if water is accumulating. If this happens no superheating results, only evaporation of the water. At the present day (1916) superheaters are again coming more to the front, but are still very far from being in universal use owing to their expense for repairs due to corrosion, difficulty of examination and liability to scoring valves and faces by the very hot and dry steam.

28. ALTERNATIVE SETTINGS.—(1) How do we obtain dry steam? What is the principle upon which the appliance acts? What care does it require? What gain results from its usage?

Ans.—The care needed is chiefly to see that the fires are not set away unless there be water in the appliance, otherwise the tubes become burnt before the steam has circulated through them. This

water forms steam of its own. The chief gain is the drier steam, causing less water of condensation in the cylinders, and so leading to increased economy. (The other answers can be as well obtained from what is already given.)

Note.—The illustration fig. 9 shows a "Robinson" superheater fitted to a marine boiler, and a brief description of this appliance is as follows :—It consists of a number of solid drawn mild steel tubes made from the best Swedish steel, and which pass inside the smoke tubes. Their ends in these tubes are formed into a thickened spear shaped head, whilst their outer ends are expanded into "headers" bolted to the boiler front. These headers are divided into several compartments, certain of which receive the saturated steam and pass it into the superheating tubes from whence it returns in a dried condition to the other compartments that communicate with the main steam pipe to the engines. The compartments are closed at the front by doors jointed down and thus will permit of the expander being operated on tube ends, or the removal of any scale that may happen to be deposited in the header.

This superheater is simple and substantial, and has not a great multiplicity of pieces, and altogether gives very good results.

29. What parts of a marine multitubular boiler are first injured by shortness of water?

Ans.—If the water level gets too low the first parts affected are the combustion chamber tops and the small tubes.

30. Where are angle irons sometimes used in the construction of a boiler, and where are flanged plates used?

Ans.—In the actual construction of the boiler no angle irons should be used, all joints being made by flanging the plates. If gusset stays are used anywhere, or main stays with T heads, angle irons are needed to secure these to the boiler plates, that is all. Such plates as the back and front end ones, back tube plate, and back of combustion chamber are all flanged.

31. Priming: to what causes is it attributed? What means are applied to prevent it? What evils may be produced by it?

Ans.—Priming is the steam carrying away with it a large amount of water caused by a very disturbed water level. This is mainly due to

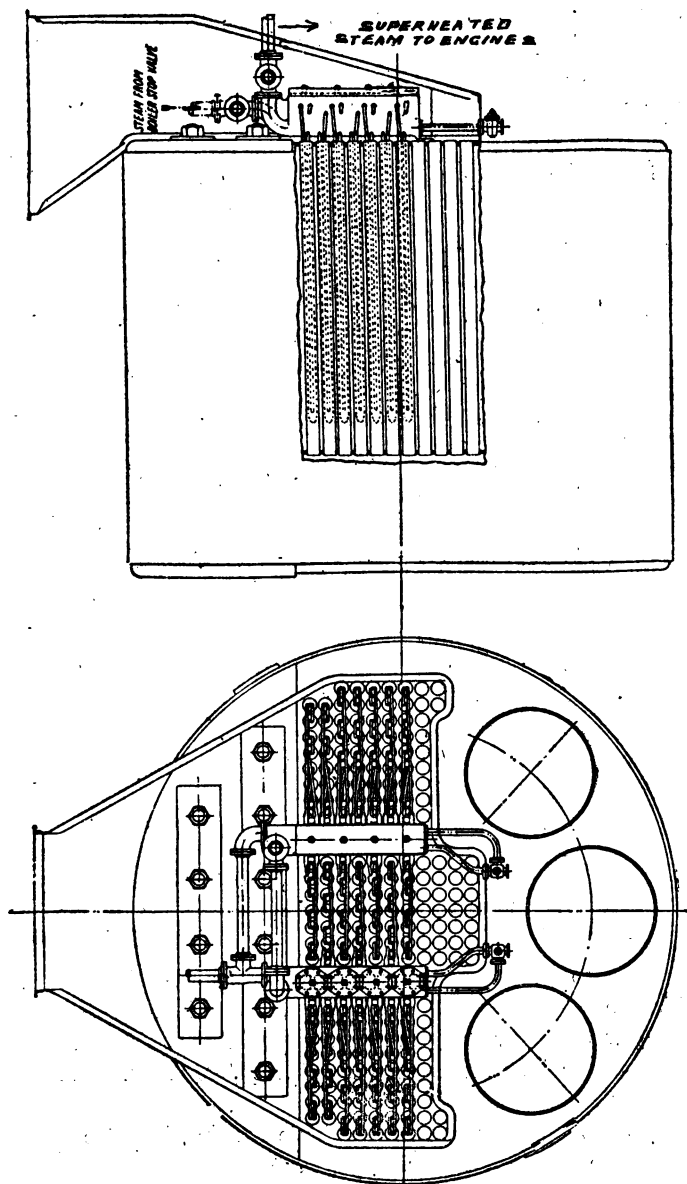


FIG. 9.

too small an area of water level through carrying it too high in the glass, or too small a boiler for the work expected from it. Other causes for the disturbance are irregular firing, the small tubes being too close together, so interfering with the free passage of the steam through the water; and the boiler water itself being dirty.

To effect a cure, carry the level in the glass as low as safety permits, keep the firing regular and the water as clean as a feed filter

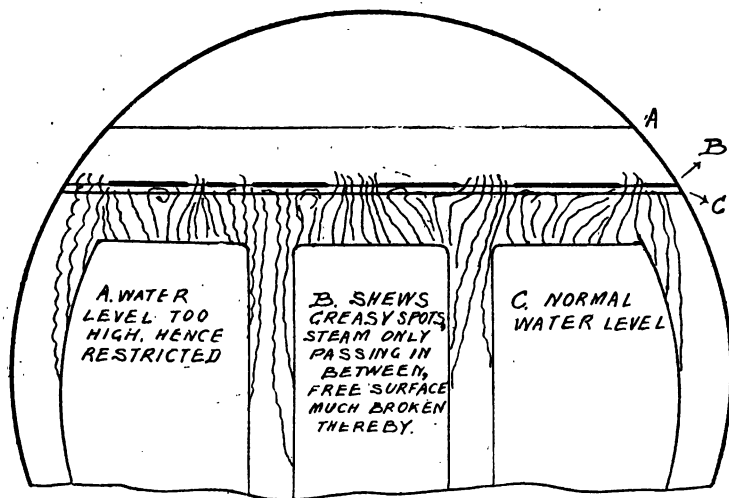


FIG. 10.

can supply, also heat the feed to promote better circulation, and even perhaps draw a vertical row or two of tubes in each box, plugging the holes to ensure tightness.

In order to prevent priming water passing over in such large quantities an internal steam pipe is fitted, having its end closed and a large number of long very narrow slots made in its upper portion. As the steam passes into the pipe through these slots the wet is scrubbed out of it by their edges.

The evils of priming are that the water getting into the cylinders may crack the piston, cylinder cover, or bottom, or perhaps actually knock these out, therefore when priming see that all drains are open and escape valves able to lift.

- 31. ALTERNATIVE SETTING.—What accident may occur from excess water in the cylinders, and how may such water get there?**

Ans.—The covers on bottoms may get cracked or knocked out by excess water, which comes over when the boilers are priming, through irregular firing, dirty water, etc.

- 32. Funnel draught; what makes it? What checks it?**

Ans.—Funnel draught is caused by the difference between the weight of a column of outside air of a height from furnace to top of funnel and the weight of a column of the hot gases of same height and area. The hot gases being light readily rise, and the cooler external air rushes in to take their place, so promoting draught. When it becomes checked it is either by means of closing in the ashpit doors or the funnel damper, or else the setting up of "downdraught" in the funnel through eddy currents about its top.

- 32. ALTERNATIVE SETTING.—What name is given to the result of having two equal columns of air, one heated and the other cool, about a boiler?**

Ans.—Funnel draught or the ability of fresh air to come in contact with the fires is caused by the difference in weight of the two columns.

- 33. Flame is sometimes seen at the top of the funnel; what causes this appearance? Is it beneficial or is it detrimental? Why so?**

Ans.—If flame is seen at the top of the funnel it is due to incomplete combustion of the gases in the boiler caused by insufficiency of air. The gases being very hot, but not ignited, owing to the air shortage, pass away through smoke tubes and uptake to the funnel, and on reaching the top of this they meet with the air they require for their combustion, and hence they ignite. It is very detrimental, as the heat which is produced at the funnel top should have been given out in the boiler, besides which it destroys the funnel itself. To make up for the loss of efficiency more fuel has to be burnt on the bars.

- 33. ALTERNATIVE SETTING.—Where may flame about a boiler and its adjuncts be a waste? How does such manage to exist?**

Ans.—(That already given does all right.)

34. A blast pipe; what is its construction? Where is it placed? For what is it used?

Ans.—A blast pipe consists of a pipe coming from the steam space of the boiler and terminating in a steel tapering nozzle placed at the base of the funnel and pointing directly up this. On the steam issuing and rushing upwards it drives out the gases ahead of it and at a greater rate than they would issue of themselves. It thus acts as an “induced” draught, because the space which would be left behind these rapidly rising gases is at once filled with more air rushing into furnace; it thus enables more fuel to be burnt properly upon the grate in a given time.

35. How many bottom blow off cocks are generally fitted to each boiler, and why are they so fitted?

Ans.—Two cocks are fitted, one on the after end of the bottom of boiler and connected by a copper pipe to the other cock placed well down on the skin of ship. Two cocks are fitted so that if the pipe breaks, neither the sea will get into ship, nor yet the boiler water escape to the bilges. They are used to remove some of the densest water and the dirty deposit which accumulates at the bottom of boilers. When using these cocks be careful to open sea one first, and close boiler one first when you finish blow down, etc.

36. Blow off cocks are sometimes fitted with a spanner guard; for what purpose is this? Describe how the guard is formed.

Ans.—As the blow down cocks must not be *left open* it is usual to fit a cap as a part of the gland, and at one place in the cap or guard a

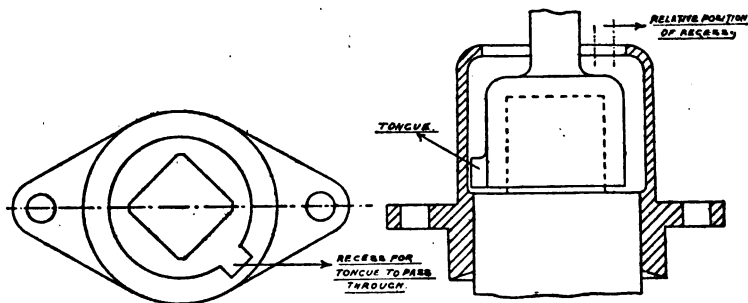


FIG. 11.

slot is formed, and through this goes a tongue forged on the box spanner used to operate the cock. Care is taken when cutting the slot to see that as the tongue comes through it, the cock is fully closed.

- 37. Water gauge test cocks; where are they placed? At what heights? Must the cocks themselves be at those heights? What provision is made for cleaning these cocks should they ever become choked? When there are no test cocks how is the height of the water ascertained?**

Ans.—Test cocks should always be placed direct upon the boiler itself. There are usually three, the middle one being at the working water level, the top one about 7 inches above the centre one and the lower one about 3 inches above the level of combustion chamber top. The cocks themselves need not be at these heights, as internal pipes can be fitted, but are not reliable. They may choke up and even though their ends in the boiler are fitted, when new, at the heights above, yet unless great care be taken, they will sag down and so give false indications of level. To clean the cocks there is a small screwed plug inserted in the bib opposite the hole through plug of cock, and on removing this a wire can be inserted and any dirt removed. If no cocks are fitted the only way of telling height of water level is to look at the gauge glass on boiler end.

- 37. ALTERNATIVE SETTING.—What takes the place of the water gauge? What faults have they? What trouble may any internal pipes in connection with them give rise to? State where and at what levels you would place these alternatives to a gauge glass?**

Ans.—(That already given does all right.)

- 38. What is a deadweight safety valve? Of what are the rubbing surfaces formed? How is a lock-up valve arranged to admit of lifting it or of turning it round, and to prevent adding to the weight?**

Ans.—It is a safety valve where the load is obtained from lead or cast iron weights placed directly upon the valve spindle and of an amount equal to the area of valve multiplied by the boiler pressure in lbs. per square inch, minus the weight of valve and spindle. The

rubbing surfaces are of brass or gun-metal. To allow for locking up, a cap is placed over the spindle where it projects up through the cover, and which cap rests entirely upon the cover. Through the cap is fitted a cotter being a fit therein, but being clear in a slot through spindle. A lock can be inserted in the end of this cotter to prevent its withdrawal. Handles and easing gear are fitted to turn and lift the cap,

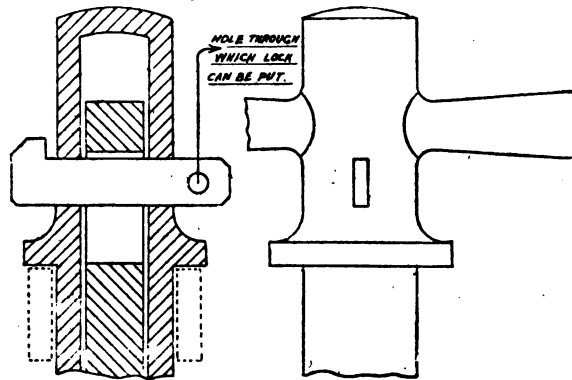


FIG. 12.

and by means of the cotter these movements are given to the spindle, and as this is loosely connected to valve by a pin, the desired easement, etc., is effected. As the cap is *closed* at the top no extra weight can be put on spindle. Clearances of $\frac{1}{4}$ valve diameter should be allowed between top of spindle and inside top of cap; between top of weights and cover and between bottom of cotter and bottom of cotter slot in spindle, to allow valve to lift without moving the cap.

38. ALTERNATIVE SETTING.—What takes the place of a spring or a lever loaded safety valve? What faults has it? Can it be tampered with? Can the valve be moved from the outside of the chest?

Ans.—In addition to what is already given, the faults may be, serious loss of pressure when ship rolls or pitches, liability of valve to stick up, inability to readily adjust for desired alteration in safe boiler pressure, and clumsiness generally of the design, if made for high pressures.

39. About what area of safety valve is now required by the Board of Trade? What is the effect of suddenly opening a safety valve when steam is up? To about what extent do safety valves rise when blowing off, without being eased by hand?

Ans.— $\frac{37.5}{\text{gross pressure}}$ gives the part of 1 square inch area of valve per square foot of grate, thus if the steam be 160 lbs. gauge, we have $\frac{37.5}{160 + 15} = .214$ square inch, and if there are 54 square feet of grate, $54 \times .214 = 11.556$ square inches area of valve. On lifting a valve suddenly, priming is very likely to result because the steam in its rapid exit through the opening at valve and seat carries up with it a large amount of water, and so if we have to ease the valves by hand do so gradually *not* suddenly. Valves when blowing off naturally, merely lift clear of the seat and probably not more than about $\frac{1}{20}$ inch or less, but at the instant of going up they may lift for much more, but come down again at once.

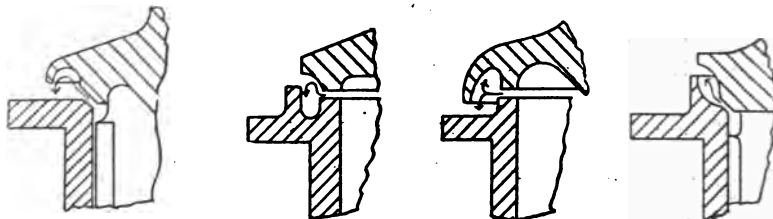
39. **ALTERNATIVE SETTING.**—Give the rule by which safety valve area is computed, and also say what lift you expect when a valve is steadily blowing off. If a safety valve sticks and allows pressure to accumulate and then suddenly rises far beyond the normal, is there any danger?

Ans.—(That already given does all right.)

40. Spring loaded safety valves; what advantages have they that are not possessed by deadweight valves? What are the disadvantages, if any, as compared with deadweight valves?

Ans.—Their advantages are as follows:—No reduction in load or liability of spindle to jamb when the vessel heels, elimination of the huge mass of the weights as in a deadweight valve, and consequent greater ease and ability for overhauling. Their disadvantages are practically nil, about the only one being a slightly increased compression and hence more load, as the valve blows off, but this is overcome in a well designed valve by forming a lip as shown in fig. 13 upon which the issuing steam

can act and so find a greater area and thus overcome the little extra load. Broken springs are seldom met with.



VALVE LIFTED IN ALL VIEWS TO SHOW ESCAPE OF STEAM.

FIG. 13.

41. Of what pieces does a glass water gauge mounting consist? How does it act? Where is it placed? At what height? Is it liable to derangement? How is its working tested?

Ans.—The glass water gauge consists of a cast iron or cast brass column either solid in the centre or else formed as a tube, *i.e.*, hollow. At the top and bottom, flanges are cast to receive the steam and water pipes respectively leading to the top and bottom of boiler. Bosses cast on the column also towards the top and bottom are screwed and receive the steam and water heads consisting of asbestos packed cocks and special stuffing boxes with glands to take the gauge glass, the water head also having a drain cock with it. The glass being in free communication with the boiler water, this rises to the same level in both when glass has been just blown through, and thus is seen whereabouts the water is in the boiler. They should be placed close up to the boiler and in a position where the glass is readily seen. The height of the bottom or water head (cock) should be from 4 to 5 inches above the combustion chamber top and length of glass is about 18 inches. It is liable to become choked at the plugs, especially the water end, and if the level of the water be observed to be stationary, the glass should be blown through by opening the drain, after closing alternately the steam and water ends, by the double shut off method. (For description of this see Question No. 220.)

42. Glass water gauges have sometimes pipe connections top and bottom. What is the object of this arrangement? Should there be cocks at the extremities of these pipes? Why, or why not?

Ans.—The object of the steam and water pipes is to ensure a

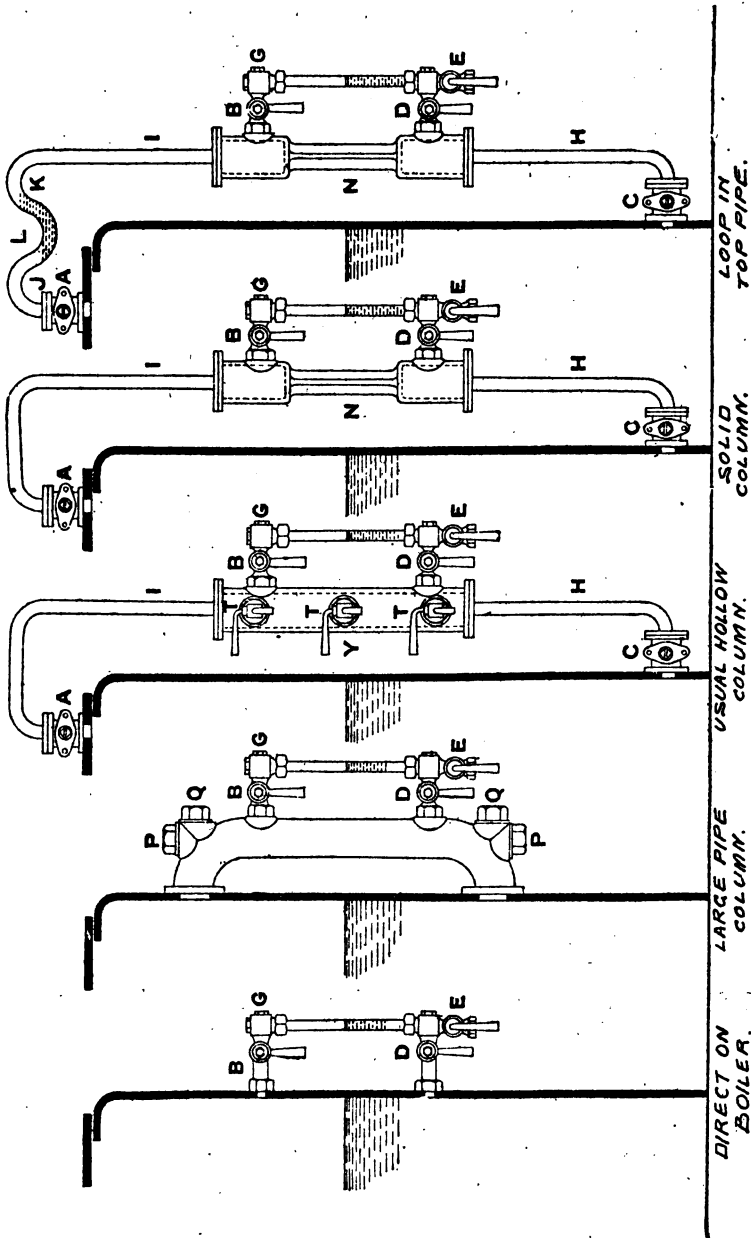


FIG. 14.

steadier level in the glass, by taking the steam from a high point above the place of greatest priming, and the water from a place below where the ebullition due to steam formation on combustion chamber backs is the greatest. There should always be cocks fitted at the boiler ends of these pipes in case they split, so that all steam and water can be shut right off (see fig. 14).

- 42. ALTERNATIVE SETTING.**—If a glass water gauge is directly attached to the boiler is its reading reliable, and if not, why not?

Ans.—(That already given does all right.)

- 43. Describe a Bourdon steam gauge. Some gauges have an inverted syphon pipe below them; what is its use?**

Ans.—A Bourdon pressure gauge consists essentially of a small curved tube of elliptical section (see fig. 16), having its outer or free



FIG. 15.

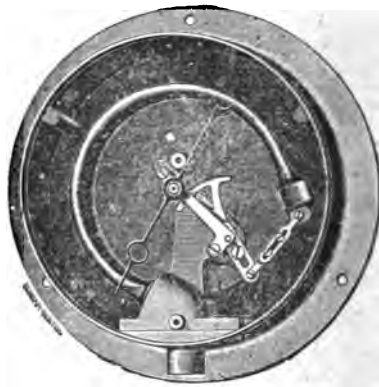


FIG. 16.

end closed and its fixed end in connection with a pipe coming from the boiler. The free end is, by means of links and gearing, connected to a pointer which revolves round a dial on the face of the gauge, and this dial is marked in divisions indicating lbs. per square inch pressure, above the atmospheric pressure. Under the action of the internal force from the steam the elliptical section tends to become circular, and at the same time the whole tube tries to straighten itself out, so pulling upon the links and gearing and turning the pointer until the "spring" of the tube balances the effort of the pressure and the pointer

then stops opposite the reading corresponding to that boiler pressure. In order to keep the high temperature steam off the tube a syphon pipe is fitted and contains water, and it is this water which transmits the pressure of the steam actually to the tube.

44. Why is a small cock sometimes put on the pipe leading to a steam gauge? Where should it be placed, and what error might be made by omitting to use it?

Ans.—When the gauge is not in use, and even when it is, the steam would condense in the pipe leading from the boiler and so a gradual filling up would result, and for every 2.305 feet the water rose above

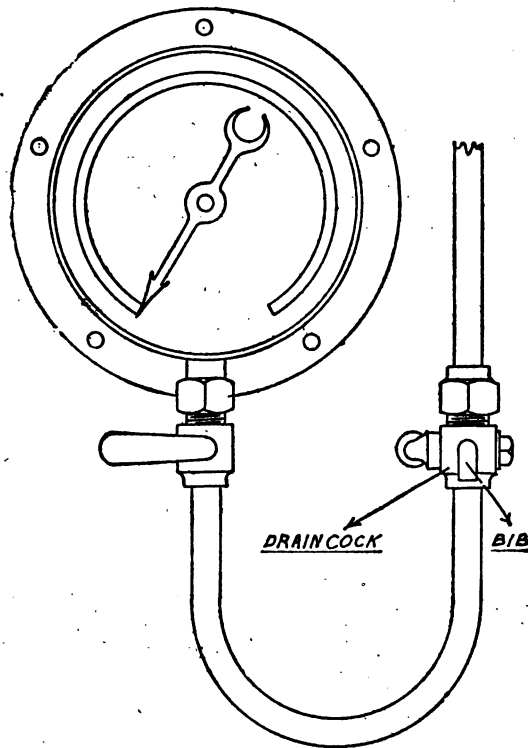


FIG. 17.

the level of the gauge 1 extra lb. pressure would be shown. Therefore the drain cock must be placed on a level with the gauge, and then when blowing the water out of the pipe above it will be impossible to empty the syphon which must remain filled.

- 45. Do steam gauges indicate the total pressure of the steam or only a portion of that pressure? What is the pressure measured from?**

Ans.—A steam gauge only registers the pressure above the atmosphere, and to obtain the real or gross pressure the barometer reading in inches must be halved and *added* on to what the gauge shows. Thus, say barometer at 29.5 inches, pressure gauge showing 180 lbs., then real, gross, or absolute pressure is $\therefore \frac{29.5}{2} + 180; 14.75 + 180 = 194.75$ lbs. It is usual to allow 15 lbs. as the pressure of the atmosphere if nothing to the contrary is stated.

- 45. ALTERNATIVE SETTING.**—If all pressures could be measured from zero or 0 lbs. what would the pointer on a steam gauge now showing 160 lbs. read?

Ans.—It would stand at 175 lbs. or gauge reading at present plus the gain in visual amount due to the pressure measuring from 15 lbs. lower than at present.

- 46. What is meant by the salting of the boiler? How is this prevented? What is the density of ordinary sea water? How is the density ascertained? What is the difference between the formation of scale and the salting of the boiler? What is the maximum density at which boilers should be worked at sea? In the event of condenser tubes leaking, what is the minimum density at which boilers should be worked? Give your reasons.**

Ans.—By the phrase “salting of a boiler” is meant the water becoming so dense that the salt contained in it is likely to deposit upon heating surfaces, etc. To prevent such, use the blow down cocks and also the scum cock, and by their means remove a certain amount of the *very* dense water and replace by an equal volume from the sea. Average sea water contains 5 ozs. of soluble matter per gallon, about $\frac{3}{4}$ of which is ordinary salt (chloride of sodium). To ascertain density we employ an instrument called a salinometer, which, on being allowed to float, shows on a graduated stem the total number of ounces solid matter present, and not merely the salt. Scale is formed by the lime and magnesia matters contained in sea water becoming insoluble after

a temperature of about 280° F. is reached, and depositing upon all the heating surfaces as scale, whereas the salt is quite unaffected by temperature, and will only deposit if the water becomes practically saturated, that is, at a density of $\frac{1\frac{1}{2}}{3\frac{1}{2}}$, when it can hold nothing more in solution.

Boilers at sea if worked with supplementary salt feed may go as high as to read $\frac{3}{3\frac{1}{2}}$ to $\frac{4}{3\frac{1}{2}}$, but if worked with a good non-priming evaporator the density will be little above 0 or fresh water mark even after long runs. (This assumes boiler at first filled with perfectly fresh water.) If the condenser tubes leak at all badly, work to the $\frac{3}{3\frac{1}{2}}$ or even perhaps $\frac{4}{3\frac{1}{2}}$, as by so doing only $\frac{1}{3}$ (or $\frac{1}{4}$) of the feed requires blowing out, and if we kept boiler at say $\frac{2}{3\frac{1}{2}}$ then $\frac{1}{2}$ the feed would be blown out in the same time, and the greater the blow off, the more scale forming matter comes into the boiler.

47. Scum cocks and pipes; how are they arranged? Where are they placed? At what height in the boiler? When are they used? When must they be shut? Neglect of these cocks leads to what dangers?

Ans.—Scum cocks are fitted to the shell of boiler and have an internal pipe reaching out towards the middle of the water level and at the outer end of which pipe is fitted a shallow pan being arranged about

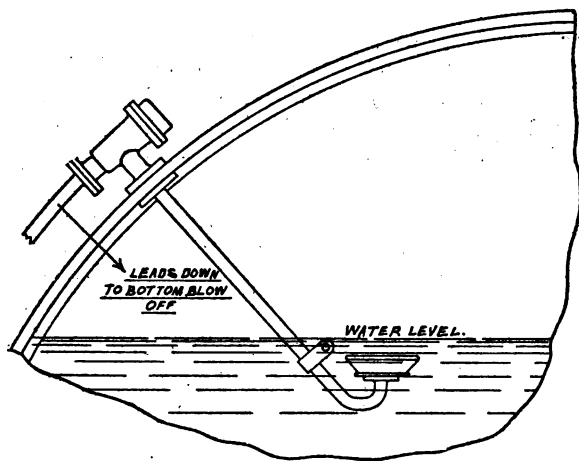


FIG. 18.

2 inches or so below the usual working level. From the outside of the cock a pipe leads down to either the ship's side, being fitted there to a

cock, or else the scum pipe is led into the main blow down pipe. The object of scumming is to remove the dirt and general impurities floating at or about the water level and consisting of inorganic matter (dirt) and greasy patches, these being brought to the surface, the latter because they are lighter than the water and the former by reason of a film of steam forming round each little piece and so rushing it up to the water level, where the steam film breaks away from it. If boilers are filled with dirty river or dock water they will require more scumming than if filled with a clean sea or river water. Scum cocks must be shut *before* the level of the water reaches the exact top of the pan, also they must be shut when engines are stopped, or no water being fed into boiler, else the steam will rush through and be a dead loss. As it is, scumming always means losing some good water which must be made up again preferably from an evaporator. If these cocks are not well looked after, cleaned whenever the chance allows and worked at short periods they will salt up and become set fast and by refusing to open may allow a very high density to accumulate with a possible risk of salting of the boiler.

47. ALTERNATIVE SETTING.—If a scum pan be placed too low what happens? How does this "scum" originate? What faults do scum cocks suffer from?

Ans.—If placed too low an undue amount of fresh water will be blown out *before* the scum comes down to the level of pan. (Second question already answered.) One of the principal faults is the plug getting salted up and incapable of being turned. Other faults are the pan coming off, internal pipe choking, or perhaps it breaking short off.

48. Of what does scale consist? Where is it most objectionable? How is it removed? How is its formation prevented? What evil effects are produced by it.

Ans.—Scale consists chiefly of sulphate of lime, chloride and sulphate of magnesia with a small amount of carbonate of lime. It is objectionable on the heating surfaces such as furnace crowns, combustion chamber backs, sides and tops, tube plates and smoke tubes, as a very thin layer of scale increases the coal consumption by a very appreciable amount. It is removed by means of chipping chisels and scaling hammers, care being taken to see that the plates are not damaged by these. Its formation cannot be *entirely* prevented, as

even the so called fresh water contains carbonate of lime, but by excluding all sea water from the boiler, using a good non-priming evaporator for all "make up" feed and by the use of a little carbonate of soda dissolved in the boiler water, scale can be kept down to a very trifling amount. The evil effects from scale are the one mentioned above and the even greater trouble of the plates overheating owing to the scale preventing the water getting to the plate to carry off the heat, hence these soften and the pressure in the boiler pushes them in, and bulged combustion chamber plates and flattened or collapsed crowns result.

- 48. ALTERNATIVE SETTING.**—Can scale form if water be entirely free from salt? If free from lime and magnesia as well as free from salt, does it form? What must also exist before scale can form?

Ans.—If boiler water is entirely free from lime, salt and magnesia no scale could form, and if free from everything except the salt there would still not be the hard stone-like scale so well known, because the common salt (chloride of sodium) is not changed by increase of temperature, but limes and magnesia matters are, becoming insoluble as they get hotter.

- 49. What is a salinometer? Of what does it consist? How does it act? How is it graduated? Can it be used at any temperature indiscriminately?**

Ans.—A salinometer is an instrument for ascertaining the density of the boiler water. It is made of brass or German silver and has at its lower end a weighted bulb to sink it a certain distance into the water, And also a larger sized float. As it floats in the water, the level comes against one of the marks made on its stem and so the density can be read off, as this stem is graduated to read 0 or fresh water mark $\frac{1}{32}$, $\frac{2}{32}$, $\frac{3}{32}$, etc., and the spaces between are divided into parts of a 32. Many salinometers have a set of readings marked directly in ozs. per gallon, as well as the 32 scale. It must only be used in water of the temperature shown on the particular instrument and which is almost universally 200° F. The salinometer floats lower, for less density and higher for more density, hence the 0 or fresh water mark is at the top part and the divisions get smaller as one goes down the stem.

49. **ALTERNATIVE SETTING.**—What is the meaning of the word “salinometer”? Does it record the presence of anything besides salt in the water? If the weight broke off could it still be used?

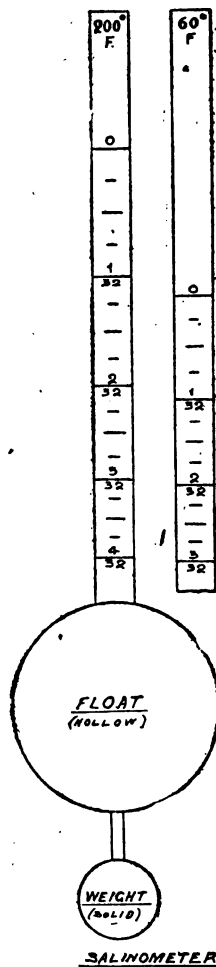


FIG. 19

Ans.—The word means “salt measurer,” but the instrument, depending for its use upon the density of the water, records the presence of anything in solution therein, and if sugar were dissolved in the boiler water the salinometer would register a higher density in consequence.

Should the weight be broken off the instrument is rendered useless, because it cannot then sink lower enough owing to the float buoying it up.

50. What harm may be done through the check valve of one of a set of boilers being defective while under way? How would you work to avoid this harm?

Ans.—If the defect is a piece of the valve having broken away, this may mean that even when the faulty valve is shut tight on its seat, yet too much feed is passing through the hole and so that boiler gets more than its share. To remedy this, ease the fires on the *other* boilers and raise the pressure a little on the one with the broken valve and the bulk of the feed will now take the path of least pressure and the amounts will thus be adjusted. Should this not do, then shut off the main feed altogether and put on the donkey pump, sending the water in through the donkey checks.

51. How is a leak from a split tube stopped in a boiler at sea? Describe the operation.

Ans.—The leak must be stopped by fitting a plug or stopper to the tube. Thus procure a piece of soft wood, and hollow out the central portion for a length a little more than the length of split, make the plug also a good driving fit for the tube and having drawn the fire of that furnace, drive the plug down until the hollowed part comes to the split, this will be known by the leak stopping when the plug goes down the

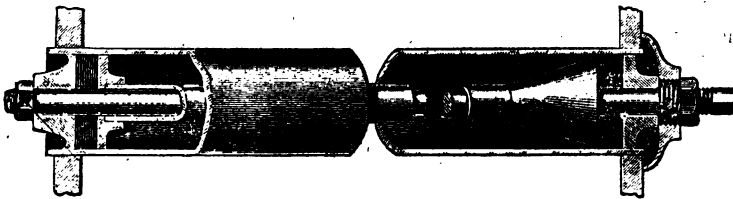


FIG. 20.

tube. Another and better method is to use a patent stopper if there is one handy, and which consists of a rod longer than the tube and screwed each end for a few inches, being fitted with nuts and washers. Also the rod carries either composition balls, or discs of an easily compressed metal (see figs. 20 and 21), and so when the whole is placed

within the split tube and the washers tightened down by the nuts, the balls, etc., squeeze out and form a steam tight joint at each end just inside the tube. If there is no patent stopper, one may be improvised thus, cut the ends of the tube flush with tube plate, screw a long bar of about 1 or $1\frac{1}{4}$ inches diameter, pass it through the tube and fit flat washers and nuts at each end, the washers larger in diameter than the tube and with jointing material or asbestos sheet, between washers and plate, screw the whole lot up tight.

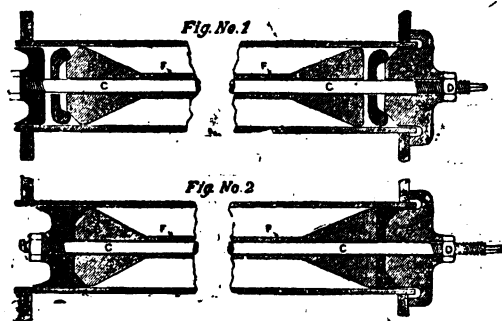


FIG. 21.

Note.—Fig. 20 shows a patent tube stopper as made by Messrs. Murray, McVinnie & Co., Ltd., of Glasgow, and it follows the principle of having discs of compressible material squeezed up by stout washers and nuts, the square on end of central rod being to receive a spanner in order to prevent its turning as the nuts are tightened. Fig. 21 shows Messrs. Beldam's patent stopper and to effect a cure against leaking enter the disc *E* from smoke box end of burst tube and drive it through and its sharpened edge acts as a cutter, removing sooty scale, etc. Having placed the stopper in the tube, see fig. 21 (fig. 1), screw up nut *D* and the discs *A A* will then be forced up to the cones *B B* and when screwed tight, these discs will fill the coned spaces and make a steam-tight and reliable job, see fig. 21 (fig. 2).

52. What is the use of dampers? Where are they fitted? When should they be used?

Ans.—Dampers are used for checking draught in boilers, and give a better and safer control over this than by opening the furnace and smoke box doors. They are placed in the funnel and at the mouth of the ashpits, and if steam is forming too quickly, as when travelling at

reduced speed, or when the boilers are priming, close in these dampers and so check combustion. They should be closed when engines are stopped else steam will be wasted.

53. When there are no dampers fitted what is used instead? What evil to the boiler is, sometimes attributed to this? When the heating surfaces are clean does this occur?

Ans.—If dampers be not fitted, the furnace and (or) the smoke box doors must be opened, and this is a very risky plan to adopt, because the cooler air striking against the hot plates and tubes causes cracks to occur and leaks to develop due to the sudden contraction. This trouble is worse on dirty tubes, tube ends, and plates, because then the plate, etc., reaches a higher temperature owing to the scale preventing the free passage of the heat through the plate or tube; therefore all heating surfaces should be kept as clean as ever possible in order to minimise the dangers mentioned.

54. Describe the piston of a steam cylinder with its different rings and their uses. There are generally round pieces let in flush on one side of a piston; what are they? How are these pieces fixed?

Ans.—The ordinary or common box type of piston consists of a cast iron hollow disc having a central solid portion bored out to take the piston rod. The lower edge of the disc is a flange turned to a working fit in the cylinder, and which flange serves as the support for

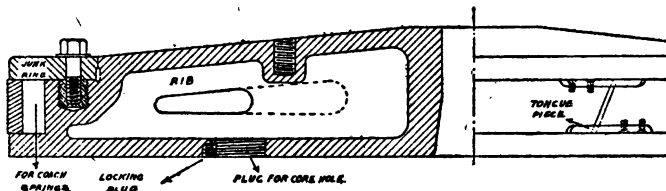


FIG. 22.

the packing rings which may be either of the plain Ramsbottom type or a ring which is kept out against the cylinder walls by springs behind it. This form of packing ring has a tongue piece fitted across where it is cut, and which tongue is a fixture in one end of the ring, but is

free to move parallel to ring in the opposite end, and its object is to prevent steam passing by the space between the adjacent ends of the packing ring. The packing ring or rings are held in place by a solid ring called the "junk" ring, which is a trifle smaller in diameter than the cylinder, and, being bolted down to a recess turned on the top of the piston, keeps the packing rings so that they may move out to the walls of cylinder, but *not* up or down. The cores for the hollow of the piston are supported through, and later on removed through, holes left in the underside, and these are afterwards filled with fine threaded plugs screwed in flush and kept in place by means of locking plugs, tapped partly in core plug and part in piston.

- 54. ALTERNATIVE SETTING.**—Pistons of smallish diameter are nowadays made differently to what they used to be. What is the present method? How are they kept steam tight in the cylinder?

Ans.—High and intermediate pressure pistons are often made of cast steel, coned shape, and the cylinder covers and bottoms, are coned to suit. This style makes a lighter and stronger piston, and to keep them tight, ordinary Ramsbottom packing rings are inserted.

- 55. Cylinder drain cocks; what is their use? There is sometimes a valve upon each cock; what purpose does it serve?**

Ans.—The use of cylinder drain cocks is to clear the water out which may collect in the cylinders through condensation or priming. Those for low pressure cylinders or engines in connection with the condenser should have a species of non-return valve fitted that whilst allowing water, etc., to be blown out will shut tight if any *air* tries to rush in, thus preventing the vacuum being impaired.

- 56. Cylinder escape valves; of what do they consist? How protected? How regulated? When are they most needed? To what danger do they expose the engineer? What precaution is sometimes used to obviate this danger?**

Ans.—A cylinder escape valve consists of a brass spring loaded valve and brass seat let into the cylinder cover and bottom. A screw

and washer pressing on the top of the spring gives the load, and is regulated generally when the engines are first set away by slacking back the screw until valve lifts each stroke, then tightening down a little until it keeps closed. There will then be a pressure of a lb. or so mor

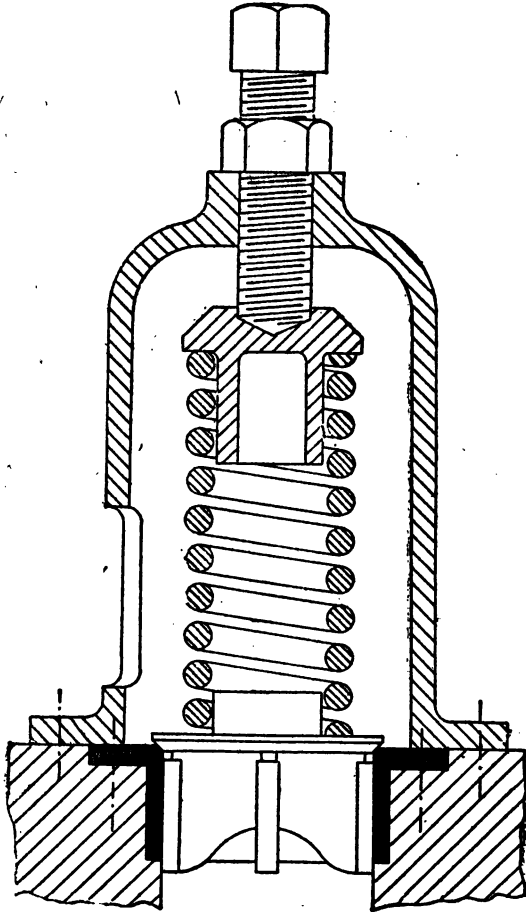


FIG. 23.

than the working pressure in that cylinder, and if an *increase* of pressure arises the escape valve at once lifts and releases it. They also act in the event of any sudden priming occurring, and to prevent this scalding water flying on to the engineers, guards or domes are fitted, and it is

the top of these which supplies the necessary nut for the compressing screw to go through. The domes are secured to the cylinder cover or bottom, and often have a pipe fitted to lead the water clear away to the bilges.

57. What is a compound engine? What different kinds are there for screw steamers, in respect to the number and arrangement of their cranks and cylinders? What is a triple expansion engine?

Ans.—The name "compound" engine is given to one where the steam is expanded in more than one cylinder, that is, a certain amount or volume of steam is supplied to the smallest diameter cylinder, and this amount (bar losses) works its way through the one, two, or three cylinders of increasing size which follow the one it was first sent into, thus a compound engine enables us to obtain the economy due to high pressure steam, without making the working parts heavier, and also keeps down the loss by range of temperature in the cylinders. The earliest arrangement of a compound engine had one high pressure cylinder and one low pressure of an area about four times that of the high pressure and was known as a two-stage compound. Its cranks were set at 90° to each other, though in a few cases, when the low pressure would have been of too great an area, it was subdivided between two more moderate cylinders, and so the sequence was high pressure, low pressure, and low pressure, with three cranks at 120° to each other. In some old engines only one crank was used, and then the high pressure cylinder was placed on top of the low pressure, and one long piston rod took both pistons.

A triple expansion engine is one where the steam expands in three cylinders, each of increasing diameter, and at times the large low pressure cylinder is divided into two, and then there are four cranks each at 90° , but usually the triple expansion engine has three cranks at 120° to one another. It can, however, have only two cranks at 90° , and then the high pressure cylinder will be placed above either the intermediate pressure or low pressure cylinder. The natural sequence of a triple expansion engine being high pressure cylinder forward, the intermediate (or mean) pressure one in the centre, and the low pressure one aft. The usual ratio of cylinders is somewhere about $1 : 2.6 : 7.5$. A quadruple or four-stage expansion engine is also a "compound" one, only having four cylinders of increasing diameter instead of three.

57. ALTERNATIVE SETTING.—Is a quadruple expansion engine a “compound”? If so, what do you really mean by the phrase “a compound engine”?

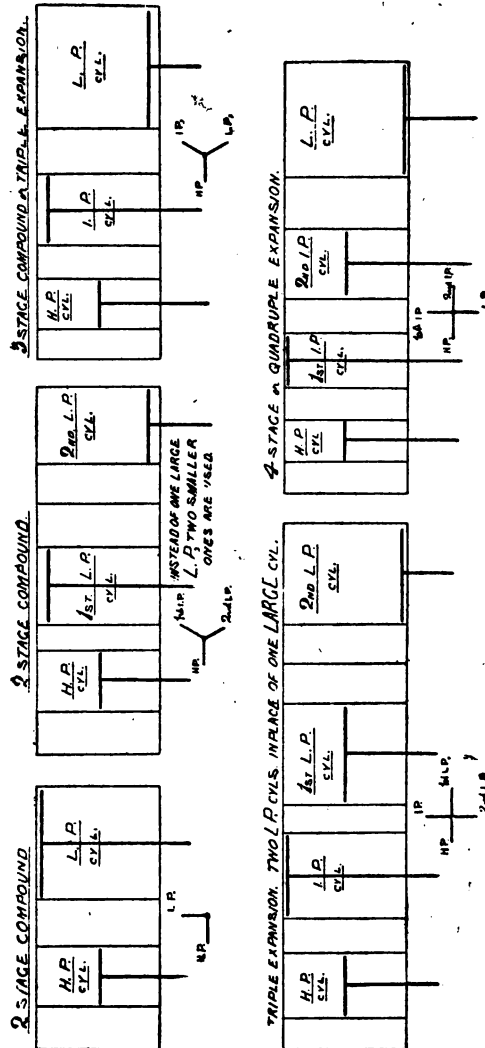


FIG. 24.

Ans.—Yes, a quadruple expansion engine is certainly a compound one, as that name means any engine wherein the steam expands in successive cylinders of increasing size.

58. What is link motion? What are some of its advantages? In modern engines for the screw propeller, when there is no link motion, what takes its place?

Ans.—This is the ordinary name for the gear employed to drive the slide valve and which gear consists of two eccentrics and straps with eccentric rods going up to the ends of a slotted reversing link which slides to and fro over a tumbling block attached to the end of the valve spindle. The link has fastened to it the two "drag" rods or links coming from an arm on the reversing shaft, and the normal position of the above link motion is with the headway eccentric rod in line with the spindle and to reverse it is only necessary to push or pull, by means of the drag rods, the link until the end of the sternway eccentric rod has come underneath the spindle. About the only advantage this link motion possesses is the ability to use the steam more expansively, as by "linking up" (removing the eccentric rod a little from exactly in line with the spindle) the cut off by the slide valve is made sharper. When no link motion such as above is fitted, some patent gear like Marshall's or Joy's is used.

58. ALTERNATIVE SETTING.—If the reversing link were made straight instead of curved could the engine run? What advantage has a long link over a short one? Is link motion easy to reverse?

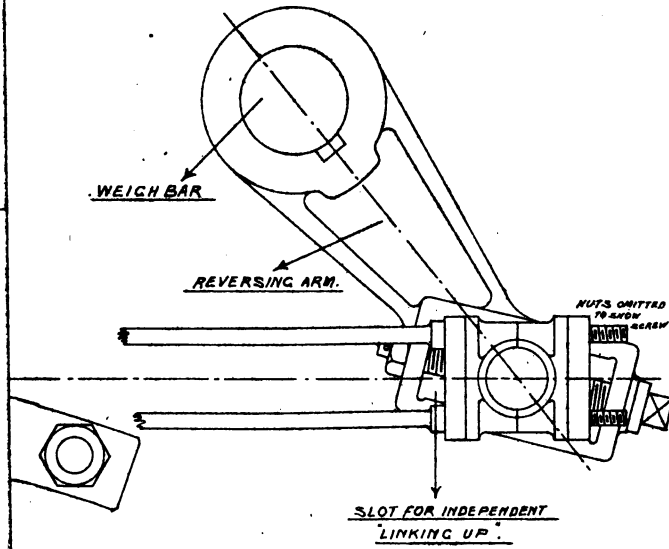
Ans.—The engine would run all right with a straight link, and when in full gear little or no change would be noticed, but when linked up the change in leads would be pronounced. A long link allows much more "linking up" to take place, as one turn of the wheel only moves the link along by a small amount, whereas with a short link a turn or two of the wheel, while moving the link actually for the same distance, yet has brought its mid position much nearer the spindle than if the link be long.

An ordinary link motion is not an easy one to reverse, and it is for this reason that an engine is fitted to run the links over. If done by hand it would be a tedious operation.

59. What is a separate expansion valve? Why is it not fitted to all engines? What effect has an expansion valve upon the starting and upon the reversing of the engine?

Ans.—This is a slide valve working upon the back of the ordinary or main valve and by means of which the steam is cut off at much

PLATE I.



LINK MOTION.

SHOWING THE MAIN PARTS, BUT A
MINOR DETAILS ARE LEFT OUT.

To face page 42.

earlier parts of the stroke than the main valve alone could do. It is generally only fitted to the high pressure valve where an engine is designed to have a separate expansion, the reason being that this is

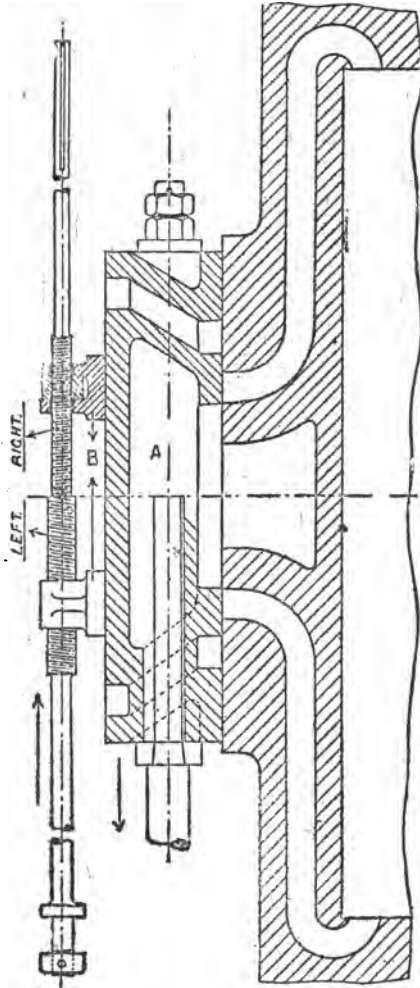


FIG. 25.

the controlling cylinder and if the horse power desired is to be less, then by the separate expansion valve, sharpen the cut off on high pressure and that reduces the *whole* horse power, If fitted to the intermediate pressure and low pressure cylinders it would only alter

the individual powers, but leave the total as it was before. An expansion valve of the "Meyer" type as is shown here does not as a rule interfere with starting and reversing of the engine, as its sheave is placed with the line of throw at 180° to crank, *but* if it had been set to give very sharp cut offs, then perhaps on starting the bars would require a little closing together to enable sufficient steam to enter the ports to start the moving parts.

Note.—Readers would do well to consult *Brown's Slide Valve for Engineers*, which contains a very good account of this expansion valve.

60. What arrangement is applied to reduce the friction of a slide valve? To what is the friction due?

Ans.—In order to reduce the friction it is necessary to reduce the area of the back of valve against which the steam presses. To do this,

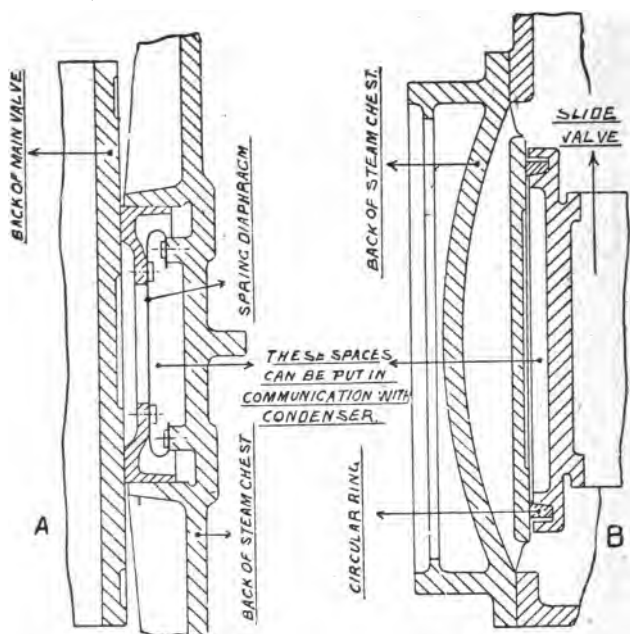


FIG. 26.

some form of circular ring, truly faced up, is held against the planed surface of the back of valve and also in a circular recess formed in the steam chest door (or back), or else the ring is attached to a solid

diaphragm plate and the space so formed by valve, ring and plate, etc., is put into communication with the condenser and thus not only is the valve eased by having a less area for steam to act against, but actually there exists an effort to draw the valve away from cylinder face. The friction is due to the pressure of the steam forcing the flat valve hard against the cylinder face.

60. ALTERNATIVE SETTING.—What faults may relief rings on slide valve backs possess? Calculate how much coal is wasted by this fault.

Ans.—The chief fault is their risk of leakage, and if this occurs the steam in the chest at once finds its way to the condenser, if valve be the low pressure one. For example, as to loss, assume the leakage space to be 1 square inch in area and steam pressure in chest at 20 lbs. gross, then each day there will be lost in steam

$$\frac{1 \text{ sq. in.} \times 20 \text{ lbs.} \times 24 \text{ hrs.} \times 60 \text{ mins.} \times 60 \text{ secs.}}{70 \times 2240} = 1.1 \text{ ton,}$$

and taking 8 lbs. of steam per 1 lb. of coal, there will be $1.1 \div 8 = .13$ ton of coal lost per 24 hours.

61. Describe a loose eccentric; how does it act? In what engines are loose eccentrics still employed?

Ans.—A loose eccentric is one which is free to turn round upon the shaft within certain limits, these being determined by stops bolted to the sheave and another which is fixed to the shaft. As the shaft revolves its stop catches against one of those on the sheave and so drives this round and by means of the gab ended eccentric rod and a rocking lever, the sheave's motion works the slide valve. (In the fig. 27 the stoppers on the sheave are formed by the balance weight.) The action of a loose eccentric is best explained by having to reverse the engine. By means of the "trippet pin" the eccentric rod is lifted clear of pin on spindle and valve is worked by hand so as to admit steam to the opposite side of piston. The engine then starts and shaft turns, but leaves the sheave standing until such time as the stopper on shaft meets the *other* face of the stopper on sheave, then steam still being admitted by the hand movement of slide, the eccentric rod is moved and when this is seen the trippet pin is lowered and eccentric rod gab drops upon the pin at spindle end and the engine works automatically

again. The engines using such loose eccentrics are mostly river boats like tugs, etc., as it forms a very quick, simple and handy means of working such vessels about in a crowded waterway.

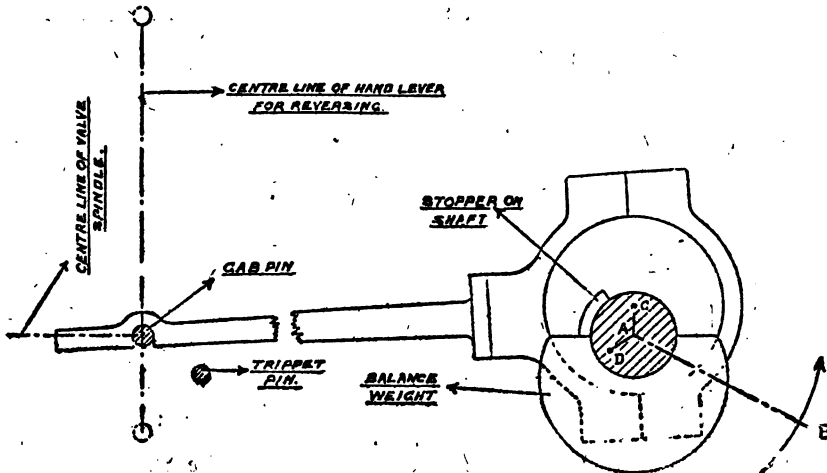


FIG. 27.

61. **ALTERNATIVE SETTING.**—What is the valuable feature about loose eccentrics? Can you “link up” with an engine employing them?

Ans.—Their great use or benefit is due to quickness in handling engines fitted with such gear, as directly the gab lever or eccentric rod is tripped clear of the pin on rocking lever the engine is under direct hand control. No linking up can be done, because the eccentric rod is lifted *clear* of the valve lever, and not merely altered in relation to it.

62. What is the travel of the eccentric rod? How is it measured on the eccentric? What is the travel of the slide valve when the link motion is in mid gear, and the engine still moving?

Ans.—By travel of eccentric rod is meant the distance its end moves in a straight line during one of its strokes. To measure from the sheave take the narrowest portion from the widest part, or if sheave be off the shaft, take the distance between centre of shaft hole and centre of sheave, multiply by two and the product is the travel. If we

know the port openings to steam and the amount of steam lap, the travel equals top lap + top port opening + bottom port opening + bottom lap.

When the link is middled the travel of the valve is twice the (lap + lead) plus or minus the extra amount due to the eccentric rods crossing or opening during a revolution.

Note.—Readers should consult the Publisher's *Slide Valve for Engineers*, wherein this latter part is fully explained.

63. What are "double beat valves"? What objections are there to their use?

Ans.—Double beat valves are simply two valves upon one spindle, both having their own seat to come down into, and used in order to have a large opening for steam without the valves being of great diameter or opened very wide. As seen from the fig. 28 these are

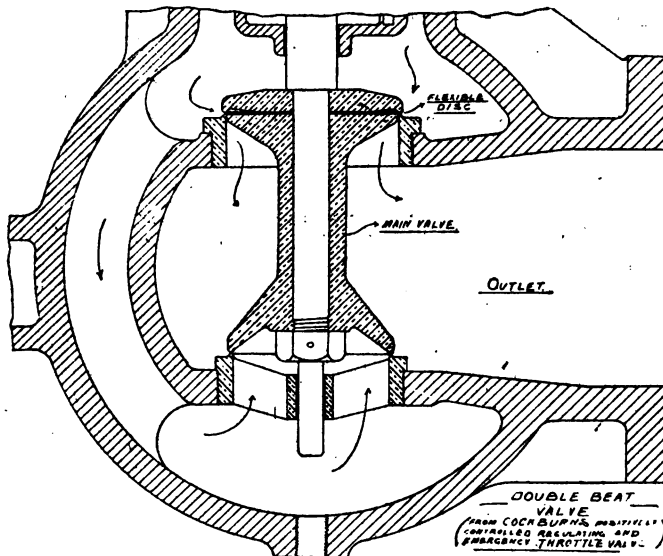


FIG. 28

partially of the nature of "equilibrium" valves, but not entirely so as the areas of the two valves are different. Whilst they are easily operated so far as opening and closing goes, the old types of such valve were subject to the serious drawback of leakage owing to unequal expansion of the

spindle between the valves and the valves themselves when heated up, and generally they require much careful attention. To get over the above difficulty of leakage, one form of present day double beat valve has the top one controlled by a spring so that if it closes first, the spindle can still be pulled down a little further (against that spring) and thus shut tight the bottom valve.

64. What is a circulating pump? Is it always worked by the main engine? Give an example from your last steamer of the three water temperatures generally noted by careful engineers.

Ans.—This is the name given to the pump which “circulates” the sea water through the condenser tubes, so cooling them and enabling condensation of the steam to be effected. The pump may be either worked by links from the pump crosshead at the back of the main engines, or it may be an independent pump of the centrifugal type, as is very common at the present day. If driven from the main engines it is usually a double-acting forcing pump and drives the water through the nests of condenser tubes and finally sends it overboard by the main discharge pipe. The separate centrifugal pump has the advantage that the condenser can be kept cool when the main engines are stopped for a time, such as working about in a dock or a river and thus the vacuum is well maintained, making the engines much handier.

The temperatures to note are those of the sea injection (possibly about 50° to 65° F.), the discharge temperature (about 90° to 110° F.) and the temperature of the feed water, which, without heaters, will be about 120° to 150° F.

Note—Fig. 29 shows a good modern form of separate condenser and independent circulating pump of the centrifugal type. The combination is a Weir “Uniflux” condenser and high speed engine direct coupled to a centrifugal circulating pump, the latter consisting of a series of vanes or impellers mounted upon the shaft and curved in such a manner that as they are rapidly rotated, the sea water which is admitted to the *centre* of the surrounding casing, is flung to the outside, from whence it escapes by a tangential branch on the casing and the rotational energy it possessed thus becomes converted into a force sufficient to send the water through the condenser and away overboard as usual.

64. ALTERNATIVE SETTING.—What pump is used to cool the condenser? What drives it? Is it a benefit to have this pump clear of the main engines?

Ans.—The pump, by reason of its work, is called a “circulating” pump, because it circulates cold sea water through the condenser tubes.

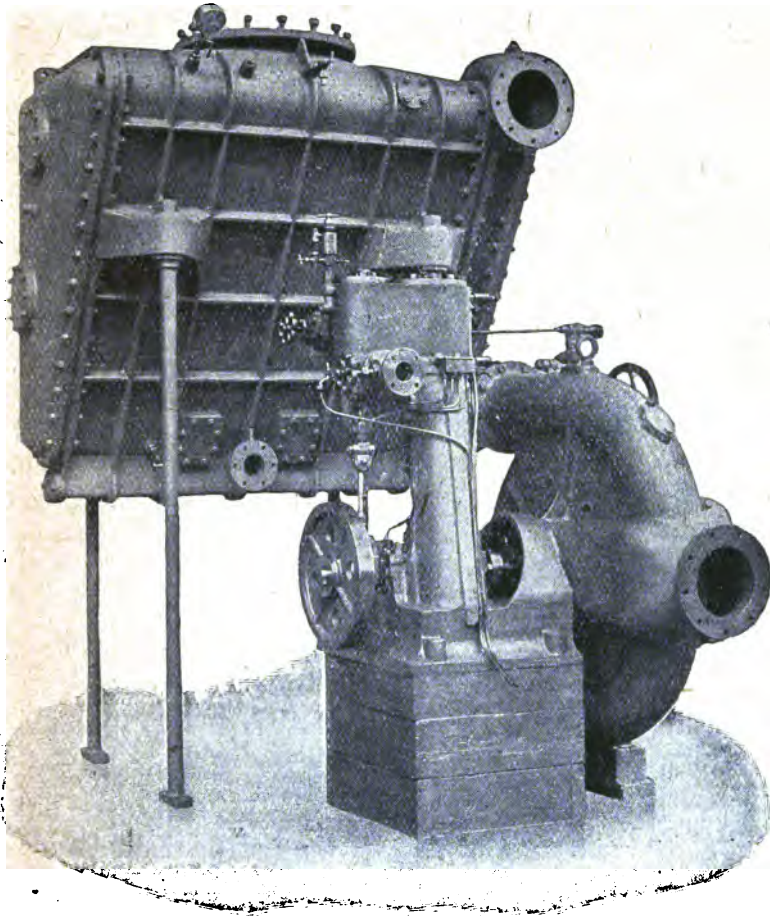


FIG. 29.

It is driven either by the main engines, or, very commonly at the present day, by an independent engine, and is then of the centrifugal type. It is better to have it clear of the main engines, as then it keeps condenser cool all the time.

65. An air valve is sometimes fitted to a circulating reciprocating pump; what purpose does it serve?

Ans.—A valve should be placed between the suction and delivery valves of the pump in order to allow a little air to pass in and so soften the otherwise hard blows on the water with each discharge.

66. What is the difference between a bucket air pump, a piston air pump, and a plunger air pump?

Ans.—A bucket air pump is of the single-acting type having a piston with a deep groove in its periphery for the reception of rope packing to ensure watertightness when working in the air pump barrel. This piston or bucket has a series of holes through it and carries over each group a set of flat metallic valves, having a hole through the

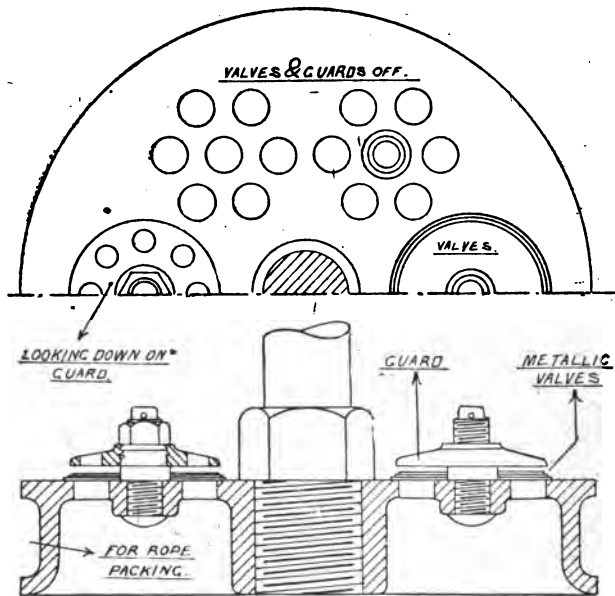


FIG 30.

centre of each for a stud taking the guard plate to pass through. There may be five or six groups of these valves to each bucket, and their function is to open on the down stroke of the pump, and the water, air and vapour which has passed into the barrel through the foot valves is now compelled to pass the bucket valves and so get above the

bucket, whence it is lifted through the head valves on the next upstroke (see fig. 30). A pure piston air pump has a *solid* brass piston and is double-acting, there being a set of suction and delivery valves for each stroke, and as the water comes into the barrel through suction valve for one stroke, the previous lot of the other stroke is forced out through its delivery valve. If this pump be fitted with a good air vessel the flow from it is practically continuous.

A "plunger" air pump is single-acting and consists of a ram working through a stuffing box exactly similar to the feed or bilge rams, and it is therefore a displacement pump.

67. Are double-acting air pumps made with plungers, with pistons, or with buckets? Describe the construction and action of circulating pumps?

Ans.—Double-acting air pumps must be made with solid pistons because they do *not* pass the water, etc., through this part, it merely enters and leaves at each end of the chamber through the suction and delivery valves placed there, that is, one set for each stroke.

Circulating pumps are of similar construction, viz., suction and delivery valves at each end, and their action is as follows:—On the down stroke of the piston water passes in through top suction valve, and the up stroke discharges this water through the "discharge" or "delivery" valve at the same time as more water is passing into the barrel through the lower suction valve. This water is then sent through the lower delivery valve on the next down stroke of the piston, and so the action is maintained at both ends.

A modern circulating pump is often an independent centrifugal one, where, through the agency of centrifugal force due to whirling the water round at high speed, it is enabled to pass through the condenser tubes and then away overboard. With this pump there are *no* suction or delivery valves.

Note.—Readers should refer to the figure and "note" accompanying Question No. 64.

38. What is an air-pump trunk? When is it necessary? How is it attached to the bucket? Centrifugal pumps; describe their construction and mode of working.

Ans.—The trunk is a long hollow casting attached to the bucket by a long bolt passing through the end of the trunk and bucket and

having a box or cap nut fitted to tighten the whole hard up. The head of the bolt is formed into a strong double eye, and takes the lower end of the rod coming from the pump lever end. Trunks are needed when there is not sufficient room for the usual pump crosshead with its links between this and the pump levers.

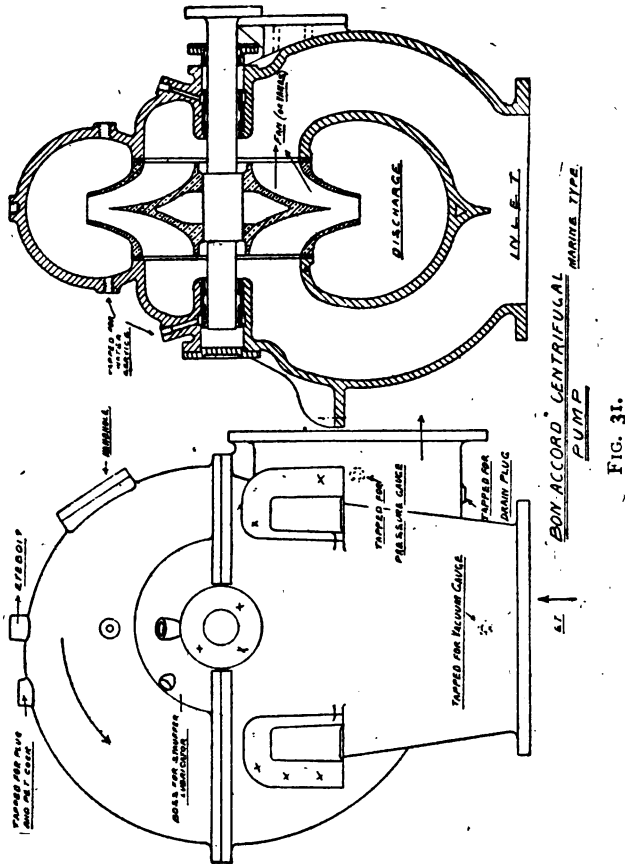


FIG. 31.

A centrifugal pump consists of a circular hollow casting having a branch leading at a tangent from its periphery. Inside this chamber is mounted, from a centre a trifle away from that of the casing, a shaft carrying a series of curved vanes which, by their rapid rotation, cause the water to fly to the outer edge whence it passes away through the

tangential branch. The vanes must revolve so as to throw the water outwards from the centre of the chamber, at which point it is admitted from the sea.

68. ALTERNATIVE SETTING. — If a centrifugal pump is driven slowly can it discharge the water efficiently? Suppose it were driven the opposite way would the water be discharged?

Ans.—As the discharge from these pumps depends upon the water possessing centrifugal force, of which a minimum amount is necessary for overcoming a given resistance, it means that a certain low limit of revolution exists for the vanes, and as centrifugal force varies as the square of the velocity, it follows that a small reduction of speed means a big loss of energy. If the vanes be driven backwards little or no water will be thrown out of the discharge, as their curvature is such as to then compel the water to close in to the centre *instead* of flying to the edge.

69. What class of air pump requires both foot and delivery valves, and in what other class can either of these valves be in some cases dispensed with?

Ans.—All double-acting and plunger types require foot (or suction) and delivery valves, but in a single-acting bucket type of air pump the foot valve can be omitted when a head valve is fitted, and provided also that the bottom of the pump is lower than the bottom of condenser, so that the water may gravitate down to the barrel and wait there for the descending bucket. This single-acting bucket style of pump would work without a head valve provided the bucket and valves were quite tight and a foot valve fitted, but usually a head valve *is* fitted as well in order to increase the efficiency of the pump.

An Edwards air pump dispenses with foot and bucket valves, but retains the head valves.

Note.—The Edwards pump, shown in fig. 32, consists of a coned piston without valves working in a chamber having ports round it towards the bottom. These ports are in free communication with the condenser and allow the air and vapour to pass to the top of the piston, when this is at its lowest point, without having to come through the water seal as usually exists with the old style of air pump. The water flows by gravity to the coned bottom of the chamber and rests there

until the coned lower part of the piston displaces it with increasing velocity up and in through the above ports to the top of piston, by which time this latter has started to come up again, and hence carries with it the water, air, and vapour and discharges these through the only set of valves (head ones) this pump has. This pump never misses its

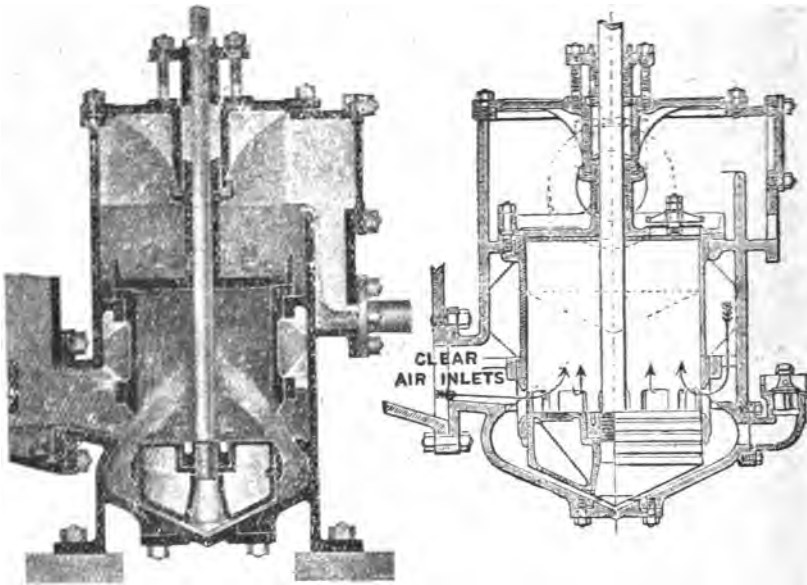


FIG. 32

water, will run at very high speeds, takes hot water (comparatively speaking), and has much less chance of breakdown than the old type. Round the piston it should be noted are cut "water grooves," and these filling constitute the packing, and thus the troubles incident to some turns of rope are eliminated.

70. What are marine governors? What is their general construction? How do they act?

Ans.—A governor is a mechanical appliance for controlling the throttle valve of the engine, closing it in as she tends to race away, and opening it out as she tends to slow down. They all consist of some attachment working the throttle valve, and the means of doing

this varies with individual makes. Thus Aspinall's type depends upon a heavy weight actuating either of two pawls, which in turn control a lever capable of opening or closing the throttle, and being fixed to the pump levers the heavy weight lags behind as the engines work faster, and this results in moving one pawl so as to operate the lever, rods, and throttle to close this latter in. As the speed of engines then falls the weight follows the movement of lever and so brings the other pawl into touch with the lever, and the first pawl having by this reversal been put out of action the next stroke of pump lever opens out the throttle, and so the actions continue as long as the tendency to race is present.

A more anticipatory type is that of Kerr's, where the throttle is controlled by electrical means which depend upon the varying head of water at the ship's stern. Put briefly, this governor consists of an anticipating cylinder at the aft end of tunnel and open to the sea through a cock, a double relay cylinder fitted at the engine and with piston rod attached to the throttle, and, lastly, a set of Leclanche cells with the necessary wiring between the anticipating and relay cylinders.

The action is as follows :—When the stern rises the head of water in anticipating cylinder becomes less and its piston descends, bringing the anticipating switch into gear and so closing the circuit. This energises an electro magnet or solenoid which brings the relay cylinders into action, and the top of the piston whose rod is attached to the throttle is thus opened to the condenser, whilst the bottom is open to the atmosphere, and thus a pressure exists due to the intensity of vacuum, and the piston is driven out and so closes throttle. Next, as the stern goes down and the head of water increases, the anticipating cylinder piston rises and in so doing breaks the circuit. A spring on the spindle of the solenoid then forces this plunger outwards, and in so doing reverses the actions above and the relay piston is driven in and opens the throttle.

Note.—For the benefit of candidates we have inserted diagrams of this governor and append a more detailed description in order to make the actions clearer.

Figs. 33, 34 and 35 show a diagrammatic arrangement of this governor, fig. 33 giving elevation of sea cock on skin of ship as well as the "anticipating" cylinder *A*, whilst fig. 34 shows the "relay" cylinder *R* on trunnion bearings upon a bracket from the engine column. Fig. 35 showing the anticipating cylinder and switches. In fig. 33 *B* is a battery of Leclanche cells and Q_1 , Q_2 and Q_3 are hand switches so placed that the relay cylinder may be operated from any place required

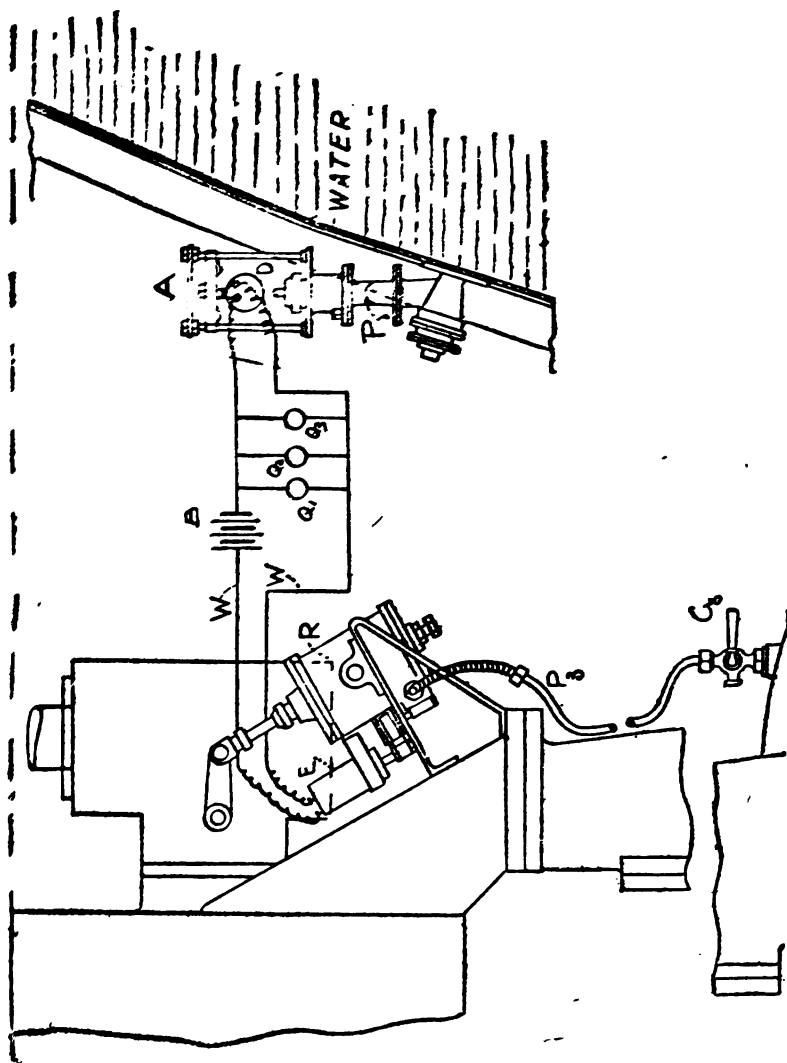


FIG. 33.

in order to obviate the labour of working the throttle hand lever, or to stop the engines quickly in case of accident.

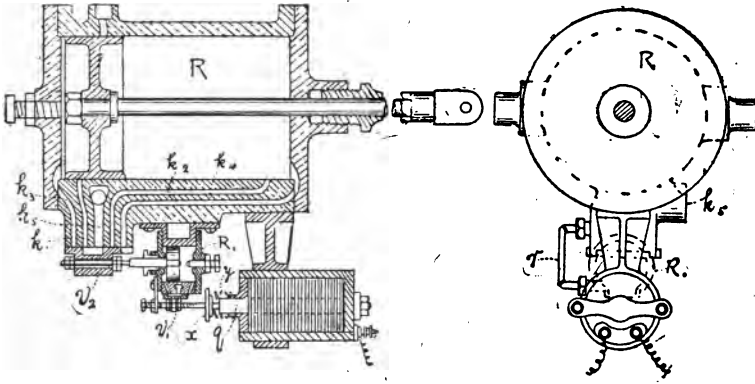


FIG. 34.

The anticipating cylinder, fig. 35, has a plain piston, p , that under normal conditions is forced up against a leather washer, W , held in place by a screwed head. A flange on this cylinder carries three pillars, two of which act as guides for the crosshead C while the other supports the anticipating switch D . The piston rod has three adjustable tappets, t_1 , t_2 and t_3 which engage the horns h_1 and h_2 of this switch and throw it in or out of contact. To alter the sensitiveness to anticipate racing, regulate tension on springs S_1 and S_2 , while for non-racing, raise or lower t_2 relatively to t_1 which should be set between h_1 and h_2 when piston is at top of cylinder. The usual working distance is $\frac{3}{8}$ to $\frac{1}{2}$ inch. When S_1 and S_2 are adjusted so that their downward effect on piston is more than that due to the pressure of the water head at which propeller begins to accelerate, the piston descends *before* the propeller can race, t_1 engages h_1 and the circuit is completed, bringing relay cylinder into action and closing in the throttle. As stern continues to rise, piston goes lower and t_2 passes below h_2 , but when stern begins to sink the piston rises, due to the now greater head of water and t_2 moves h_2 up so as to break the circuit, when the throttle again opens; t_3 is for use in very heavy weather when rapid pitching occurs and acts similarly to t_2 .

Fig. 34 shows the "relay" cylinder consisting of a small primary relay cylinder R_1 with slide valve v_1 , and whose spindle is controlled by the solenoid a . Also main relay cylinder R with its slide valve v .

operated by the primary relay piston rod. Cylinder R is provided with a double set of ports, etc., and its piston rod actuates the throttle. When throttle is open, piston is full in as shown and u_2 in its extreme back position. Port h_1 is open to condenser through exhaust passage in u_2 and port h_2 , while h_3 is open to the atmosphere, h_4 being closed to both condenser and atmosphere. When, as explained before, the circuit is completed, solenoid core is drawn in and moves u_1 forward, opening back port of primary cylinder to atmosphere and the front one to condenser. Primary piston then moves inwards carrying with it u_2 ,

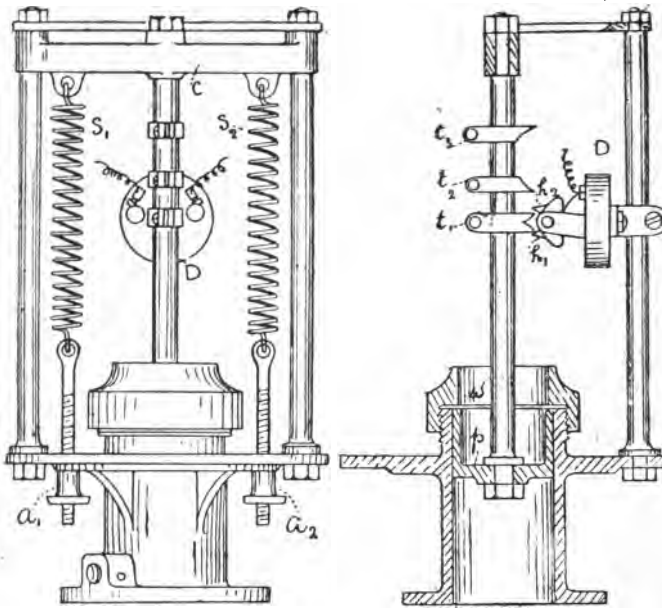


FIG. 35.

so opening h_3 to atmosphere and h_2 to condenser, and thus the air pressure forces main piston along and closes in throttle. When piston passes edge of h_2 any air left in front is cushioned and thus knocking is prevented. When circuit is broken the reverse occurs, thus the spring y forces out the solenoid core, bringing u_1 back so that the opposite side of primary piston is opened to condenser and the atmosphere forces the little piston, together with u_2 , back, this in turn opening h_1 to condenser and h_4 to atmosphere, resulting in the main piston being driven inwards and opening throttle. The speed of piston

can be controlled by partially closing cock C_3 on condenser, fig. 33 and the exhaust of primary cylinder is connected to that of the main one by the bye-pass pipe r .

- 71. With a surface condenser and a single-acting air pump what is the effect of a leaky foot valve, and what is the effect of a leaky bucket when there is also a foot valve?**

Ans.—A leaky foot valve with such a pump does not make much difference, if any, to its efficiency provided the bucket is tight. Some pumps have no foot valve fitted. With a leaky bucket and normal amount of water to deal with, the following would happen:—If say, $\frac{3}{8}$ cubic foot of water had to be lifted each stroke of the pump in order to clear the condenser, and through the leaky bucket, etc., $\frac{1}{16}$ cubic foot leaked back, there would be a rising of the water in the condenser until it made a height in the pump barrel equal to $\frac{3}{8} + \frac{1}{16} = \frac{7}{16}$ cubic foot, which is the quantity the pump would have to start to lift next upstroke. Now $\frac{1}{16}$ of a cubic foot would still leak back, but the remainder $\frac{3}{8}$ would be sent to hot well and so the new level of water would be maintained. The pump is enabled to work in this manner because normally it is nothing like full each stroke.

- 72. Where is the air pump pet cock or valve placed? How does it act? What is its object? Does it in every case reduce the effective capacity of the pump? Is it equally applicable to double-acting pumps?**

Ans.—As water is practically incompressible, when pumping it heavy shocks are experienced sometimes, so in order to soften it, a little air is admitted by fitting a pet cock or valve just below the head valve of single acting air pumps. On the up stroke it closes and the air it previously admitted cushions the discharge water and so does away with the knock or shock. So long as a foot valve is fitted and kept tight these pet cocks do not minimise the efficiency of the pump as the air cannot pass to condenser. No double acting pump has them, as the air admitted then would pass straight to condenser, there being with this style of pump no foot valve.

- 73. At what temperature is the hot well worked? What is the effect of higher temperatures? What is the effect of lower temperatures? What limits the lowness of temperature? Has a very low temperature any disadvantages?**

Ans.—A usual temperature for the hot well is between 110° F. and 130° F. If worked hotter it will mean less vacuum and hence less work from the low pressure cylinder as well as impairing the working of the feed pumps, owing to the larger amount of vapour coming off from the hotter water. If worked at a lower temperature more cooling water must be sent through the condenser to condense the same quantity of steam. This means a loss of work at the main engines themselves, and whilst we get a little more from the low pressure cylinder owing to a better vacuum, yet the feed being colder means more fuel expended in the boiler to turn it into steam. Also with a cold feed the circulation in the boiler would not be so good. The real limits to lowness of temperature are the inches of vacuum required and the temperature of the sea.

- 73. ALTERNATIVE SETTING.**—If you want to save coal and ease the boilers, what would you do with the feed? Suppose you carried this too high, what results? What loss do you have about the engine by carrying out what you propose?

Ans.—(That already given will do for this.)

- 74. Bilge injection with jet condensers; what are the fittings required? When is it used? What precautions are necessary in using it?**

Ans.—A valve or cock is attached direct to the condenser and a lead pipe led into the bilge, a strum being fixed on its end. As the air pump creates a vacuum in the condenser the atmospheric pressure on the bilge water forces it up the lead pipe past the valve, etc., and also a splash plate fitted inside condenser whereby it is broken up and enabled to come into closer contact with more of the steam and so condense it, whence the two lots of water fall to the bottom and are taken away by the air pump. Some of this water is sent to the hot well for the feed pumps and the balance and greater amount goes overboard through the

air pump discharge valve. The only time a bilge injection is used is when more water comes into the bilges than what the bilge pumps themselves can deal with. Great care must be taken to see that main injection valve on the side of ship is closed so that all water is drawn

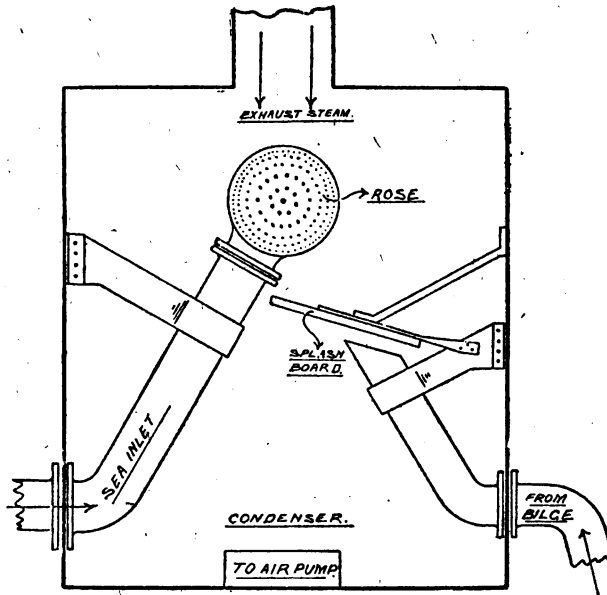


FIG. 36.

from bilge only, also to ensure that strum is clear and when finished with the bilge injection, to close its own cock or valve before opening the main injection again, otherwise the air would rush in from bilge and destroy the vacuum.

75. When surface condensers are used what takes the place of the bilge injection? To what is the connection made? How is its valve formed? Why is this necessary?

Ans.—With a surface condenser it is usual to place the bilge injection on the main injection pipe so that the circulating pump may either force or draw the bilge water through condenser tubes, provided we have closed first the main injection valve. There must be fitted to the bilge injection a “non-return” valve, and the usual lead pipe and

bilge strum. By a "non-return" valve is meant one that being free from the spindle will open to allow bilge water to pass, but in the event of the main injection being accidentally left open (or opened) when the

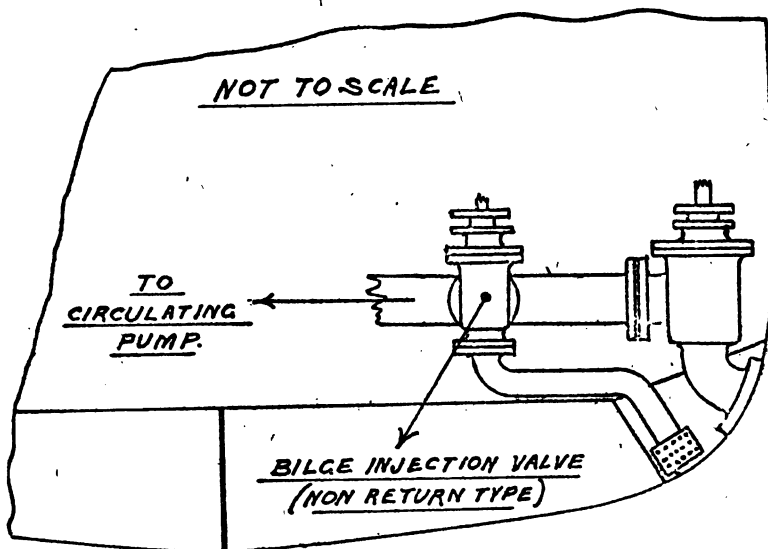


FIG. 37.

pump is stopped, there shall be no passage of the sea water back to the bilges as the valve simply returns on to its seat. These non-return valves can be fitted with screw adjustment similar to a feed check valve and so their opening regulated to suit requirements.

75. ALTERNATIVE SETTING.—What risk would be run if the bilge injection valve were made like a stop valve? What should always be fitted to prevent the valve becoming choked? Of what are the bilge pipes made? Why is this?

Ans.—(To what is already given add)—The reason for using lead for bilge pipes is that it does not corrode under the action of the acids always present more or less in bilge water.

76. What are the practical guides to the proper amount of opening of the inlet valve for the circulating pump?

Ans.—The practical guides are the temperature of the sea, the inches of vacuum required and the amount of steam to condense. If

the condenser be allowed to get too hot, there will be a poor vacuum, loss of power from L.P. cylinder but a hotter feed and so less coals used in the boilers and less work taken by the circulating pump, but the feed pumps may very likely refuse to take their water due to large quantities of vapour. If the condenser is worked very cold, it means a high vacuum and more work from L.P. cylinder but colder feed and hence more fuel needed in the boilers and greater work by the circulating pump, as more water must have been sent through the condenser, in a given time, to obtain its low temperature.

76. ALTERNATIVE SETTING.—Suppose you found the condenser very hot what would be the cause? If only hot at one end what is the cause and which end would be the hot one?

Ans.—If condenser heats all over it is a sign that the circulating water is too little and may be caused by chokage at inlet rose plate, or circulating pump valves carried away, or more steam coming to condenser than what the given opening of injection valve will pass water for, or the water itself at a very high temperature (as in the Red Sea). If only one end heats it will be the end opposite the inlet, and is due to the division piece on door at inlet end having broken away, thus allowing the water to pass straight up and away to discharge, cooling that end of condenser, but allowing the other end to heat up.

77. Feed pump pet cock or valve; where is it placed? What is its use? How does it act? Is it always a necessary fitting?

Ans.—The pet cock should be placed between the suction and delivery valves of the pump and by its admitting a small amount of air it softens the working of the pump, preventing shocks and knocks on the discharge stroke. It also enables the engineers to see if the pump is working correctly, but it is not always fitted, as air, even in small quantities, is best kept out of the water going into boilers.

78. What are some of the ways of fastening the ends of surface condenser tubes? About what size and about what thickness are condenser tubes? What parts of a surface condenser are made of brass?

Ans.—The commonest method at the present day is to form in the tube plate a small stuffing box at each hole and to screw in a gland.

The space round the tube is filled with cotton packing soaked in linseed oil, and when the gland is screwed tight down a sound watertight joint

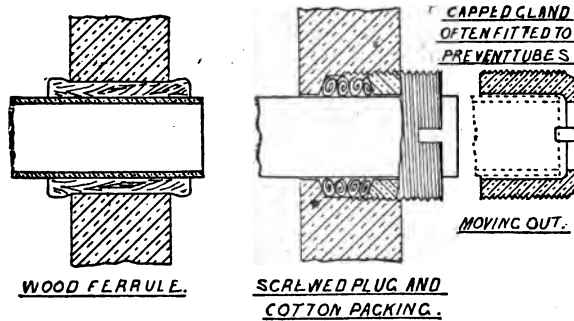


FIG. 38.

is made. Another method is to bore the holes in tubeplates much larger than the tube itself. Then to force in a wooden ferrule made of willow or pine which has previously been compressed and soaked in oil. When this gets wet it swells and makes a tight joint, but is liable to shrinkage and subsequent leakage of the tube ends if condenser gets hot. The tubes are of brass about No. 18 S.W. gauge (.048 inches) which is nearly $\frac{1}{16}$ inch thick, and are about $\frac{3}{4}$ inch to $\frac{7}{8}$ inch in diameter outside. The parts made of brass are the tubes, tube and middle bearer plates, and the studs for these plates.

78. ALTERNATIVE SETTING.—What fault has a wood ferrule for condenser tube ends? How are the tubes prevented from coming out? What is done with a split tube, and which kind of tubes are most likely to split?

Ans.—(To what is already given and shown in fig. 38 add)—The brazed tube is much more likely to split, and at the brazing, than is a solid drawn one, and when so split plugs of soft wood must be driven in at each end in order to prevent the sea water passing through to the steam side of condenser.

79. What is a blow through valve or cock? To what is it attached? There is sometimes a valve which, when opened, admits steam from the slide valve casing to the exhaust port; what is its use? To which cylinder is it fitted?

Ans.—A blow through valve is for the purpose of blowing all air and water from the condenser previous to starting the engines. To do this

it is fitted to the steam chest of the L.P. cylinder and some arrangements admit the steam by the exhaust port, others sending it direct to top of condenser. If neither of these methods is adopted, the steam can be admitted into the eduction pipe and so to the condenser. If after the blow has been on for a short time, the injection is opened, a vacuum will be formed greatly helping the starting of the engines.

79. ALTERNATIVE SETTING.—How do you drive air and water out of a condenser before starting engines? Why is this done? How is it carried out?

Ans.—(That already given will do).

80. What are snifting valves? Why are they generally omitted now?

Ans.—They are a small non-return valve fitted to the lower part of condenser or air pump barrel. Being free to lift they rise and allow the escape of air, vapour and water from the condenser when it is being blown through. Also they act as a relief valve should an excess pressure arise in the condenser, etc. The vacuum keeps the valve tight against its seat normally and so no air can pass into the condenser. The need for these valves is not so great with a triple compound engine as with the old type of single cylinder, because we are not so dependent on the vacuum for starting with, still snifting valves are fitted and usually so with the Edwards form of air pump.

81. What connections are generally fitted to the donkey pump, and to what services can it be applied?

Ans.—The connections to the donkey pump vary a little with different steamers, but a good arrangement is as follows:—The suction to be able to draw from the sea, hot well, bilges and ballast tanks, and to discharge to deck, overboard, condenser, sanitary tank, distiller, and boiler (either sea or fresh water feed), and both the main and donkey boilers. The above refers to the general service donkey.

81. ALTERNATIVE SETTING.—How do you manage if the feed pumps fail you? And if the circulating pump breaks down what pump is the most readily put on to do its work?

Ans.—(That already given will do).

82. When the engines are stopped in harbour with steam up, what are to be shut and what are to be opened?

Ans.—When stopping for more than a few moments, close intermediate stop valve (or throttle valve if this be quite tight) and the injection. Also close funnel and ashpit dampers and shut off the evaporator if this has been working. The check valves can also be closed, and if fed from independent pumps these latter must, of course, be stopped first. Ease the safety valves a trifle and open steam on to the reversing gear engine, also open the different drain cocks and change over the exhausts of such auxiliary engines as fan, dynamo, freezer, or centrifugal circulating pump on to the auxiliary condenser, if there is one. If the engines are finished with, the discharge, feed, and bilge valves must be closed also.

83. How is an engine heated up before starting? What precautionary examinations are made before starting?

Ans.—To warm an engine through before actually starting, see that all drains are open and the various valves of the engine and pumps free to move. If an "all-round" reversing gear is fitted, give steam to its engine so as to very slowly move the links to and fro, this will move the slide valves a small amount and let the steam have a chance of getting into more of the cylinders, and if it can work through to condenser pump a little water through this to keep it cool. Then open main and intermediate stop valves together with throttle valve, and also admit a little steam through the starting valve on I.P. or L.P. engine. Before starting see that main injection and discharge valves are open, also feed valves and checks, likewise the bilge pump valves. Also see that propeller is free, that the turning gear is clear and crank pit empty. Also make sure the cylinders, chests and pipes are drained of accumulated water.

83. ALTERNATIVE SETTING.—Are there any precautions to take with such as stop valves when raising steam?

Ans.—All such as main and intermediate stop valves should be eased off the face ere steam rises, then shut down again just sufficient to ensure tightness. If this is not done it is often found that a valve which has been hard closed when cold is jammed fast when it has become heated, and perhaps cannot be opened.

84. What is an interceptor or catch water? Where is it fixed, what is its construction, how does it act, and what attention does it require?

Ans.—An interceptor is a T-shaped casting placed somewhere well in sight and inserted in the main steampipe before reaching the engines. A plate is placed at the centre of the chamber for the incoming wet steam to strike against, whence its moisture is deposited

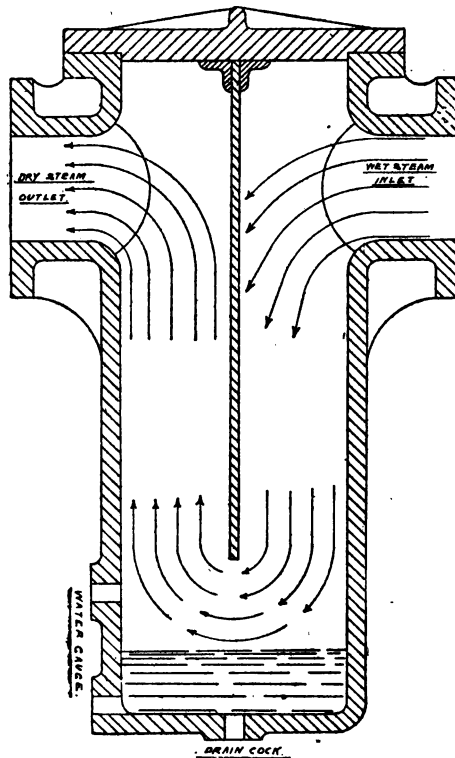


FIG. 39.

and trickles down to the bottom of the chamber. This accumulated water may be blown either into the bilge fresh water tank or into the hot well by means of a drain coming from the bottom of the interceptor. A glass water gauge is also fitted to show when it requires blowing, and care must be taken not to let the water get too high as, if so, it may be carried round with the steam and serious trouble result.

It will be seen that the steam as it leaves is very much drier than when it entered, hence an interceptor is a steam scrubber or drier.

84. ALTERNATIVE SETTING. — What quality of steam requires a drier in the steam pipe? Why?

Ans.—Ordinary wet saturated, and also dry saturated, steam both benefit by passing a drier, interceptor or catch water, before going to the engines, the former especially so, as then the priming water is taken out of it, and in the latter, though it only contains the usual moisture, yet a great deal of that will deposit out in the drier, and so the steam when in the high pressure cylinder does not facilitate "initial condensation" to such an extent as undried steam.

85. Describe an air pump bucket, with its valve or valves and its packing. Of what are the valves generally made?

Ans.—An air pump bucket consists of a cast brass piston having a central hole for the attachment of the air pump rod, and also a series of 'groups' of small holes, each group being covered with a valve or valves. These holes allow the water drawn into pump barrel on up-stroke of bucket to pass through this latter on the downstroke and so be in position ready to be lifted and discharged through the head valves. With modern pumps the valves over each group of holes consist of three thin circular sheets of muntz metal or phosphor bronze, and each set has a guard plate fitted which is usually perforated so that the water may get to the valves on the lifting stroke, and bring them quickly back to their seats, so making tightness. The edge of the pump bucket is made with a fairly deep recess into which manilla rope packing is placed, this swells when working and makes a good water tight fitting for the bucket. (See fig. 30, page 50).

India rubber valves are still met with on buckets of old design, and act in much the same way as do those mentioned above, but they are not so reliable, and tend to break and become soft under increase of water temperature.

86. Of what materials are air pump rods made? Why?

Ans.—At the present day new rods are made of muntz metal as its strength is equal to that of wrought iron, but older rods are often

found having an iron centre or core, sheathed with brass or muntz metal in order to prevent corrosion and subsequent destruction of the packing in the stuffing box. It may be mentioned that muntz metal being a species of brass is non-corrodible.

87. What is the racing of the engine? When does it occur? What danger attaches to it? What is done to prevent it?

Ans.—By racing is meant a more or less sudden increase in the revolutions of the engine, due to the propeller coming clear or partially clear of the water, owing to violent pitching of the vessel, or else such as a shaft breaking or large portion of the blades of the propeller getting knocked off. The danger caused by racing is that either the shaft or some of the moving parts of the engine may fracture, not merely due to the high speed, but also to the sudden shock when the propeller again dips into the water fully. To prevent trouble as much as possible a governor is often fitted which closes in the throttle as the engines begin to run away, and opens it out again as they slow down. If though no governor be fitted, then an engineer should be told off to stand at the throttle and regulate this according as he feels the stern rise and fall. As a precaution, the engine could be slowed down a little all the time racing is feared and the injection reduced to the smallest amount practicable.

88. When under way, when the air pump bucket is at the top of its stroke, at what height is the water in the condenser?

Ans.—If a foot valve be fitted to the pump so that a *slightly* better vacuum may be obtained in the barrel to what there is in the condenser, the water will rise in the former to a height such as to balance this difference. For example, say vacuum in condenser $12\frac{1}{2}$ lbs. (or 25 inch), and in barrel $12\frac{3}{4}$ lbs. (25.5 inch), or a difference of $\frac{1}{4}$ lb., then as every 2.305 feet height give 1 lb. per square inch, there will be for this $\frac{1}{4}$ lb. only $\frac{2.305}{4} = .58$ feet higher in pump barrel than in condenser.

For all practical purposes though, the vacuum intensity in both condenser and barrel may be considered equal and thus there will be the height of water due to the clearance of pump bucket, plus that which has drained in from condenser during up stroke of pump.

89. What is meant by the "pitch" of a screw propeller? How is it measured?

Ans.—By the "pitch" is meant the distance the screw would move forward in one revolution, provided there were no slip, that is if it revolved in a solid. To ascertain the pitch, turn one blade of propeller vertical, then construct from laths a square capable of gripping tight to the stern frame and coming against one edge of blade. Mark the point of contact, and then with another square placed at right angles to the

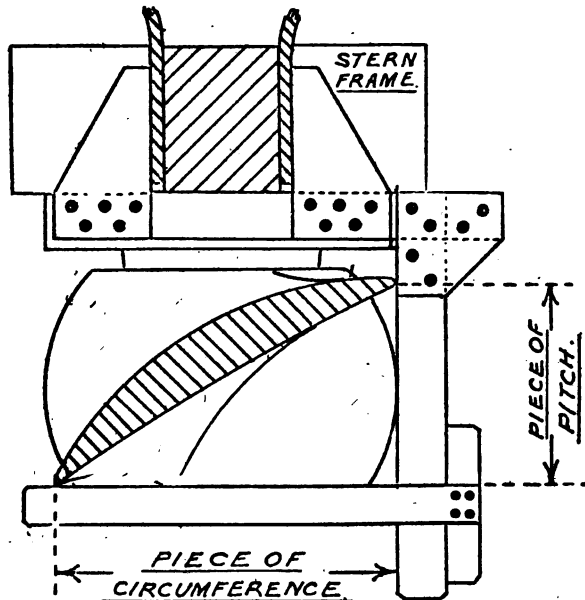


FIG. 40.

centre line of shaft bring its blade touching the other edge of the propeller blade and mark point of contact. Then measure on first lath the distance between the first scribed mark and the blade of the movable square, this gives "piece of pitch." Measure next the distance between scribe mark on movable square and the edge of lath, this gives "piece of circumference." Measure the radius of propeller blade at which you are working, and this should be at its greatest breadth, then from $2 \times \text{radius in feet} \times \pi$ we obtain whole circumference at that point, and finally a proportion as follows gives the desired pitch. As part circumference : whole circumference : : part pitch : whole pitch, or as $c' : C' :: p' : P$ whence $P = \frac{C \times p}{c}$

90. Explain the difference between a "right hand" and a "left hand" propeller, and state how each of them revolves.

Ans.—When viewing the propeller from aft looking forward, the edge of the blade which is furthest from us determines its hand, thus if the right-hand edge be furthest away it is a right hand screw, and will turn from left (port) to right (starboard) over the top. If the left edge be furthest off, then it is a left hand screw, and will revolve from right (starboard) to left (port) over the top. The foregoing edges which determine the style of propeller are, of course, the "leading" edges.

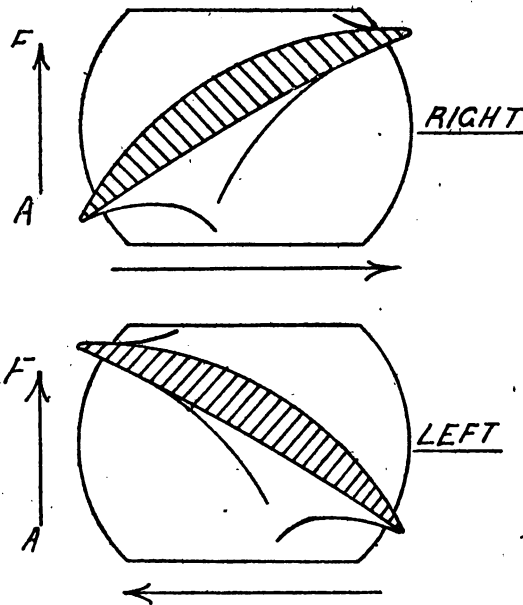


FIG. 41.

90. **ALTERNATIVE SETTING.**—Suppose a right hand propeller should have the hole bored taper from the wrong end of boss does it thereby become a left hand screw?

Ans.—No, the fact of the boring out being done wrongly simply makes the driving face of blades come at the back of propeller; in other words, the more convex surface now drives aft the water, and does so most inefficiently. No right hand thread is made a left hand one merely by turning end for end.

91. What is the slip of a screw propeller? How is its amount expressed in figures?

Ans.—By slip is meant the amount lost in each revolution by the screw working in a yielding substance instead of a solid. This is called positive apparent slip, and is calculated as follows :—Say screw is of 18 feet pitch, turning 64 revolutions per minute, and ship's speed is 10 knots per hour. Engine knots are $\frac{18 \text{ ft.} \times 64 \text{ revs.} \times 60 \text{ mins.}}{6080 \text{ ft.}}$
 $= 11.36$ per hour, hence $11.36 - 10 = 1.36$ knots of slip. Expressed as a percentage upon the engine speed this is $\frac{1.36 \times 100}{10} = 13.6$ per cent.

Real slip is the sum of the apparent slip plus the speed of the wake (or following stream of water).

There is also "negative" apparent slip where the ship travels a greater distance than pitch $\times$ revolutions in a given time, and this is due either to a current carrying the vessel in the direction of its own motion, or else by a very large "wake." By wake is meant the water that has been dragged along by the friction of the skin of ship falling away astern and so to the propeller, during which time it retains some of its forward velocity, resulting in the screw forcing *aft* water moving forward, and the effect thus produced is as though the screw were driving out a stream of water at *greater* velocity than that of its own making. This negative apparent slip is worse with very bluff-lined vessels, and though it might appear to be desirable in practice it means a loss of power because the screw is working in water greatly disturbed.

92. Which of the valves about engines and boilers have to be worked by hand, which of them are self acting, and which are worked by the motion of the engine?

Ans.—Valves worked by hand, either as a temporary measure or else solely, are main and intermediate stops, throttle valve, safety valves (by their easing gear), starting valves, slide valves (by the reversing gear), main injection and side discharge valves. As soon as steam is up and the engines working the following become automatic in action :—Slide valves, feed and bilge valves, check and safety valves, air pump discharge, and main discharge if it be not lashed up to prevent hammering upon its seat, also air and circulating pump valves, and feed escape.

93. Why is soda sometimes put into a boiler, and how is it put in when under way? What is the kind of soda used?

Ans.—Soda being an alkali neutralises the acids which may be present in the boiler water and by so “killing” them prevents, to a very large extent, pitting. The soda is known as carbonate of sodium, or common washing soda, and a further valuable property of its use is that it tends to convert the sulphate of lime, which any sea-water feed has brought into boiler, into the more easily got rid of carbonate of lime, as this latter does not form so stone like a scale as the sulphate of lime. A moderate strength solution of the soda having been made it can be introduced either direct to the hot well or else drawn up into the air pump suction from condenser, there being sometimes a small cock and pipe fitted for this purpose.

93. **ALTERNATIVE SETTING.**—If acids are present in the boiler water what do we add thereto? Do we make a weak, or strong solution, and do we put much or little into the boiler at a time? Does it cause any trouble?

Ans.—To kill the acid add carbonate of soda made up thus: In a clean bucket cover the bottom thickly with the soda crystals, fill with water to a little above their level, shake or stir for a minute or so, and pour off this liquor, leaving the crystals washed of all dirt, etc. Fill bucket with fresh water and dissolve all the soda, and put in an average sized boiler about a pint or so every watch, depending upon the acidity. Do not dose boiler with large quantities of strong solution, as this will cause priming and possibly corrosion on brass spigots.

94. Tallow cups for cylinders were sometimes made with two small cocks, or with only one small cock, or with one large hollow plug cock, or with one small cock and a valve; which of these is suitable for a high-pressure cylinder, and which for the cylinder of a condensing engine? Describe how the cup with only one small cock is used. What is now generally used instead of these? How has this change come about?

Ans.—If a tallow cup has to be fitted for a high pressure cylinder it must be of the type having a cock top and bottom so that the lower one can be closed when the cup needs refilling. otherwise when the

upper one was opened the steam would escape and might cause serious trouble and also prevent the cup being refilled.

In a condensing engine working slowly a single cock cup might answer, as we could open it and pour the tallow down during the vacuum stroke, but in any engine where the steam pressure is more than a few lbs. above the atmospheric pressure no tallow cup should be used, as tallow, being an animal fat, contains injurious acids and should be kept away from the boilers. If used where the pressure and temperature of the steam is high these acids are liberated and pass right along until they reach the boiler. In place of the tallow cup there is used an "impermeator" or "sight feed" lubricator supplied with pure mineral oil that contains no acids.

- 95. Does a cylinder escape valve, self-acting, allow all the water to escape? If not, how much is left in the cylinder?**

Ans.—An escape valve does not allow all water to be removed, because it is only brought into action by the advancing piston forcing the water in front of it and hence through the valve when it gets near the end of its stroke. Before it can open this the whole of the clearance space between piston and cover, likewise the steam passage into cylinder from slide valve face, must have become filled with water, and it is only the volume in addition to this that can be displaced by the piston, therefore the clearance spaces are *left filled*.

- 96. What is a "steam lubricator" (sometimes called an impermeator)? Explain its action. To what part of the engine is it connected? Will throwing cold water over it make it work faster or slower? Describe the one used in your last steamer.**

Ans.—An impermeator is a cast brass chamber containing oil to a certain height and having an upright pipe coming from the bottom to nearly the top. The lower end of this small pipe communicates with a gauge glass fitted with cocks and attached at the side of the chamber. From the upper gauge cock passes a pipe to lead the oil away to the steam pipe for the engines. On the opposite side to the gauge glass and at the bottom is attached one end of a condensing coil whose other end is connected to the steam pipe, and the action of the whole is as follows :—

Having placed a certain quantity of oil within the chamber to a height a little below the top of the small vertical tube, the cocks admitting steam to the coil and also allowing the oil into the steampipe are opened, with the result that the steam in the coil turns to water and is sent to the bottom of the chamber. Oil being lighter than water, it floats, and is carried up as the condensed steam gradually accumulates and very soon the oil overflows down the little vertical tube and so into the guage glass, its flow being regulated by the gauge

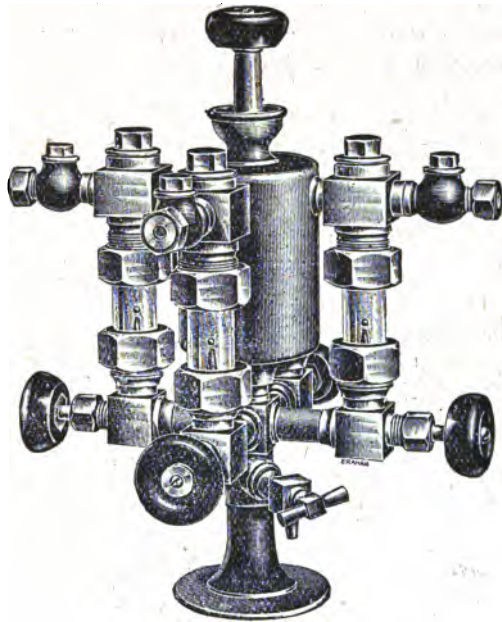


FIG. 42.

cocks. Passing up the glass it goes away by the oil pipe and so reaches the steam and gets carried to the engines. As the whole action depends upon condensing the steam in the coil it follows that throwing *cold* water over the impermeator as a whole will result in quicker condensation and so more water will go to the chamber in a given time and hence more oil be displaced. — A drain cock or plug is usually fitted to the extreme bottom of the chamber so that the water may be drained away when all the oil has gone, and also used for cleaning purposes.

96. **ALTERNATIVE SETTING.**—If more oil must be fed by a steam lubricator how do you obtain it?

Ans.—By opening the regulating valve below each little glass gauge and by pouring cold water over the coil (or other portion) in which the steam has to condense. The cooler this part is kept the quicker water will displace the oil.

97. **A common paddle wheel;** of what is the centre made? Of what are the arms formed? What is the form of the bolts which attach the floats to the arms? How are the arms attached to the centre?

Ans.—The centre of a common paddle wheel is made either of cast iron or cast steel the same as is that for a "feathering" wheel. If of cast iron it is strengthened at the ends of the shaft boss and also on the periphery, by having hoops of wrought iron shrunk and pinned on. A hole is bored to fit the shaft to which the centre is attached by a

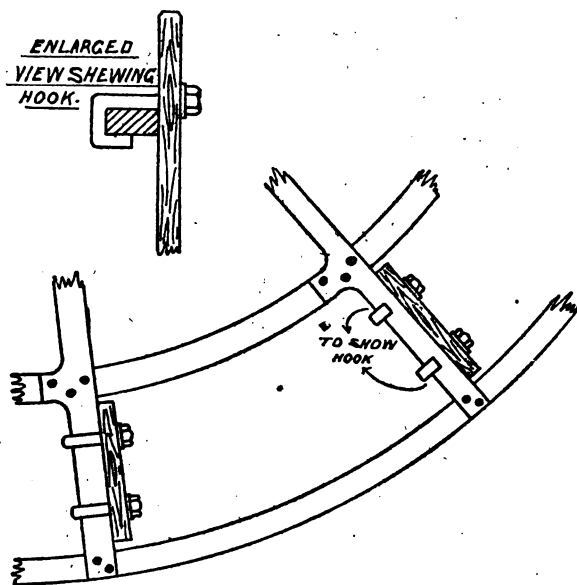


FIG. 43.

strong key. The arms are made of wrought iron or mild steel and fit into recesses cast in the "centre," being attached thereto by turned

bolts. The actual bolts used in radial (or common) wheels for attaching the floats to the arms are hooked and have their shanks screwed and a nut fitted. The hook portion clips round the framework of the wheel and the shank passes through a hole bored in the float, then a washer is slipped over and the nut hardened down on to this. Thus the float must lie at exactly the same angle as the arm to which it is fixed.

97. ALTERNATIVE SETTING.—When you speak of a “common” paddle wheel what type do you mean? Has it any faults? Do you know any design of wheel that obviates these?

Ans.—By “common” wheel is meant one of the radial type, where the floats are directly secured to the arms. It causes great shock as the very oblique blades strike the water sharply, and on leaving lift a lot with them, both being losses or faults. Feathering wheels eliminate almost entirely these troubles.

98. Why have some paddle wheels one or more cast iron floats in each wheel? With what engines are these most required? At what part of the circumference are they placed?

Ans.—Cast iron floats are placed in such a position on the wheel as to help the crank over the centre, or in other words to prevent it stopping on either dead centre, their effect being to pull the wheel round until they are at their lowest point. The engine will then have its crank ready to move when steam is admitted to the cylinder. These iron floats are required in single cylinder engines, or twin cylinder engines if they be worked disconnected. Another effect of these heavy floats is to make the engine work smoother, as when the crank is, say, coming down and the engine would like to gather speed quickly, the iron floats are having to be raised on the other side and so they check any rushing tendencies.

99. Why are paddle floats sometimes made of different breadths in the same wheel? With what description of engine is this most needed? Where are the broad floats placed and where are the narrow floats placed in the circumference of the wheel?

Ans.—The reason for fitting dissimilar breadths of floats in the same wheel is to make the turning effort more uniform. This is accomplished

as follows:—When the engine exerts its greatest effort, which is when crank and connecting rod are at right angles to each other, the broadest floats must be vertical in the water and thus driving aft the maximum amount and so absorbing the engine's powerful effect. But as the crank approaches the dead centre the effort of the engine has considerably diminished, and it could no longer impel the same sized float at the same speed, hence the narrower ones are placed so as to be vertical in the water at these periods, and thus the turning effort is carried out at a more uniform speed of rotation. Single cylinder engines require this difference in breadth, as do also twin-cylinder ones if run disconnected.

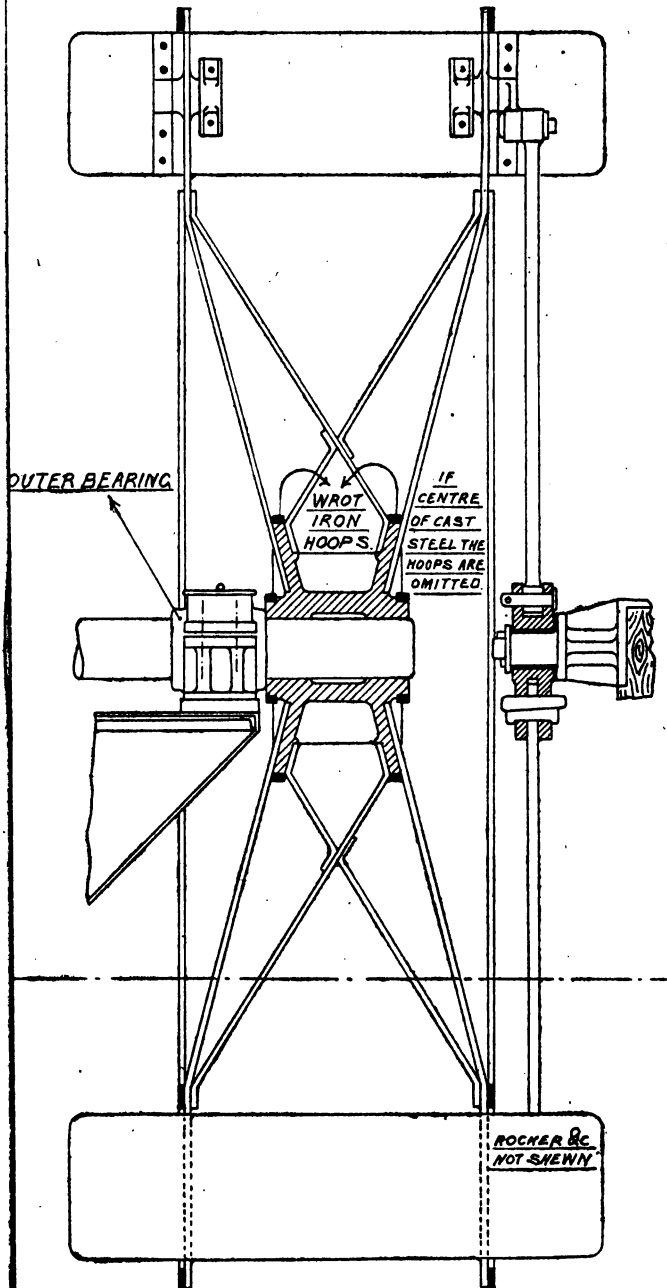
99. ALTERNATIVE SETTING.—With a single cylinder engine driving paddle wheels how is the rotation effort made more uniform?

Ans.—(That given already will do).

100. What difference is there between a radial paddle wheel and one with feathering floats? What is the object of feathering floats? Are all the eccentric rods attached in the same way, and are they all of the same form?

Ans.—With the radial wheel, the floats being fixed directly on to the arms, take the same angle as these and so enter the water with a big splash, and on leaving they raise a considerable quantity also, both acts resulting in a loss of useful work. With a feathering float, as each is free to swing upon a bracket at each arm, and is further controlled by its eccentric rod coming from the eccentric or "star disc," it is made to enter and leave the water more nearly vertical than the radial type, and thus there is not so much loss of work with a good feathering wheel. Further, the floats exert a greater drive upon the water in their passage through it. All the eccentric rods *except* one are attached to the strap by means of pins, and are free to move thereon, but the one exception is that called the driving or king rod, and this is secured to the eccentric by a gib and cottar joint, and its function is to compel the eccentric to turn with the wheel and so keep the proper arrangement of all the other rods and thus effect the feathering. It is usually made a good deal stouter than the ordinary rods, as naturally it has more stress coming on it.

PLATE II.



To face page 78.

200

200

200

200

200

200

200

200

200

200

200

200

200

200

200

200

200

200

100. **ALTERNATIVE SETTING.**—How do we obtain the floats of a feathering wheel more nearly vertical than with a radial wheel? If all the eccentric rods were free to move on the eccentric or star disc, what would happen?

Ans.—(To what is given add)—If the eccentric rods were all free the disc would remain stationary until, by the wheel turning, it had brought several of the rods all foul one with the other. The disc would then begin to revolve, but the time of moving each float would be entirely different to what it should be, and so correct feathering would never occur.

101. Whereabout is the centre of the eccentric of a paddle wheel with feathering floats placed? In that case are the feathering levers on the striking face or on the back of the float? When the paddle shaft has an outer bearing how is the eccentric made?

Ans.—When the shaft has no bearing on the sponson beam the eccentric with its pin is placed upon this latter having a lead of the centre of main shaft of from 10 to 12 inches, which thus enables the floats to enter the water more nearly vertical. The feathering rods and arms are in this case attached to the back of the floats. If the shaft

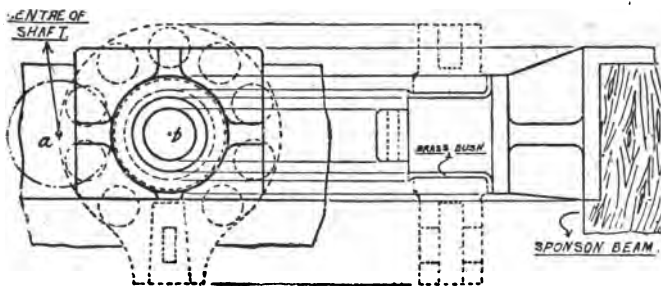


FIG. 44.

should have an outer bearing, *i.e.*, upon the sponson beam, the eccentric is usually cast in halves and forms a part of the cast iron of the bearing, or else is cast in halves and bolted to this. The distance between the centres of shaft and eccentric would still be arranged for the 10 to 12 inches lead.

102. Of what materials are the working surfaces of a paddle wheel with feathering floats? How are they lubricated?

Ans.—The working surfaces differ a little with various makers of wheel, in some the eyes in ends of eccentric rods and bearings of the rocker pins at the floats are bushed with lignum vitæ the pins being mild steel, either left plain turned or else sheathed with brass or muntz metal. In others the bearings and eyes are bushed with muntz metal instead of lignum vitæ. The lubrication is effected by the sea water.

103. What is a disconnecting paddle engine? At what place is the disconnecting effected? How is it accomplished? In which of the cranks of a disconnecting engine are the crank pins fixed?

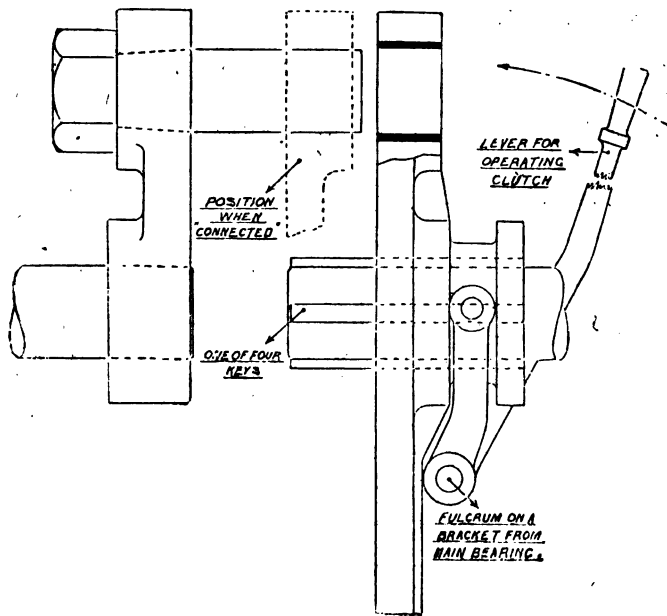


FIG. 45.

Ans.—A disconnecting paddle engine is really two single cylinder engines which can be connected together or disconnected at will, by means of a clutch sliding upon the shaft. This clutch is really a

circular web and moves parallel to the shaft upon strong keys sunk into this, and its movement is controlled by a lever working a strong fork in between collars formed on a boss at the back of the sliding clutch or web. At one place in the side of the clutch disc a recess is cast to receive the continuation of the crank pin of that engine and which pin is made a fixture in the ordinary crank web that is shrunk on the outer piece of shafting carrying one of the paddle wheels; this is usually the port side. The clutch being moved to starboard frees itself from the port crank pin and so the two engines are "disconnected" and each can control its own wheel, hence one can go ahead whilst the other goes astern and so very quickly turn the vessel round. To "connect" the engines see that the port crank pin is opposite hole in clutch disc, move over the operating lever and so push the clutch over the pin end, when the two engines will work together.

Before disconnecting can be carried out, the steam must be shut off engines and *then* the clutch can be pulled free; if this is not carried out the friction is more than can be overcome by one's hand.

103. ALTERNATIVE SETTING.—What is the common style of paddle engine to-day? If the shaft broke can the engines still be worked? What peculiarity is often noticed in fitting the crank pins of these engines?

Ans.—At the present day the commonest type is the diagonal form with high pressure and low pressure cylinders operating two cranks. The shaft here must be coupled as usual into one piece, and so if it breaks the engines most likely cannot be run, but with the older form of disconnecting paddle engines, if the middle piece of shaft gave out the engines could be run. This applies also if either of the outer shafts broke the other could still revolve.

Most paddle engine crank pins are only rigidly fixed in one web, being an easy fit in a brass lined hole in the other web, usually the outer, if not disconnecting engines, the object being to allow for the greater wear down of the outer bearing due to overhang of wheel.

104. Is link motion valve gear or the loose eccentric generally used for disconnecting paddle engines? For what steamers are disconnecting paddle engines frequently employed?

Ans.—The loose eccentric type of valve motion is employed with disconnecting engines and these latter are fitted to tugs, river ferries

and such craft as have to work their way in and about crowded rivers and must therefore be exceptionally quick in turning, etc. Note that the loose eccentric for the valve gear must be placed upon the outer pieces of shafting with a disconnecting engine so that each one may control its own sheave.

105. What are expansion joints? Where are they necessary? What attention do they require? Of what should the working surfaces be made?

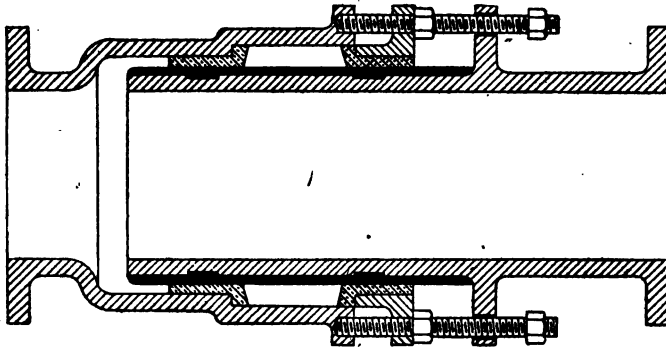
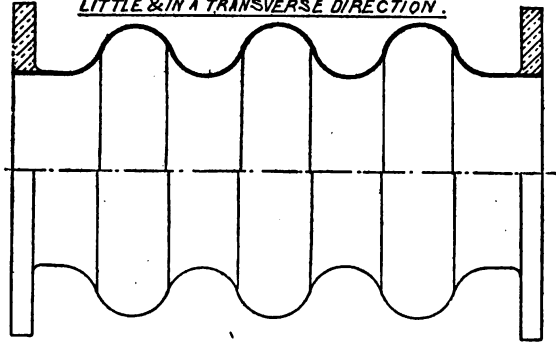


FIG. 46.

ONLY SUITABLE WHEN THE EXPANSION IS VERY
LITTLE & IN A TRANSVERSE DIRECTION.



SOME HAVE ONLY ONE LARGE, OTHERS
TWO CORRUGATIONS.

FIG. 47.

Ans.—The usual type of expansion joint is to have one end of the steam pipe brass sheathed and working in a cast iron stuffing box, fitted with a gland and specially long gland studs, the stuffing box being

packed with a few turns of soft packing and the gland tightened down just enough to ensure steam tightness. To the pipe, a few inches in front of the gland, is fixed a guard collar, and through this the long gland studs pass, having nuts on their outer ends, set up to be clear of the guard ring when pipe is cold, this clearance being greater the longer the *straight* length of pipe. Expansion joints are required in all cases where long, straight lengths of several feet of steam piping occur to allow for the expansion of this as it becomes heated, otherwise too severe stresses would be set up on whatever the ends of the pipe are secured to. If the pipe has some easy bends in it no expansion joint is required. The attention principally needed is to see that the entering end does not get jammed hard and fast in the gland and stuffing box, but remains free to move; also, that the packing does not get too hard from the high temperature. The working surfaces should always be either brass or muntz metal.

A better type of expansion joint or "box," when the amount to be allowed for is not much, is the one having two or three large corrugations worked into what is really a piece of the copper main steam pipe, and, being fitted with brass flanges, is enabled to be placed in between any two lengths of piping, and the corrugations allow of movement or working in all directions, whereas, the older type first mentioned is only of use so long as the push and pull come in a straight line.

- 105. ALTERNATIVE SETTING.**—How are stop valve chests prevented from cracking by the steam pipe heating? Are there any troubles with the special fitting?

Ans.—(That already given will do).

- 106.** What omission in the construction of expansion joints may lead to a serious accident when steam is first applied? How is this prevented in the construction of a steam trunnion pipe for an oscillating engine?

Ans.—Should the guard collar or the long studs, or their nuts be omitted, a serious accident might result from the pipe coming out of its stuffing box, and so to prevent this always see that all the above are in place.

With the trunnion of an oscillating engine the pipe cannot blow out,

because it has a bracket cast on its lower side, and this is bolted down to the engine framing, not absolutely hard and fast, but the holes in the

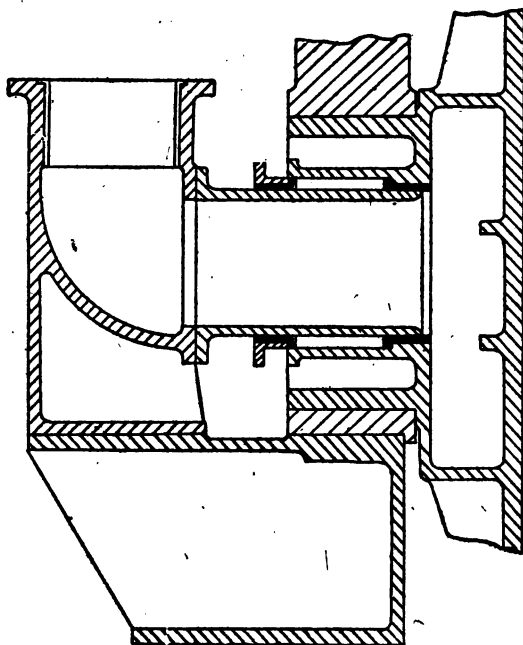


FIG. 48.

bracket are made oval to a slight extent and the nuts tightened down just enough to allow a little movement transversely.

107. Describe an oil cup with a syphon worsted? How is the worsted arranged? How is it cleaned? How far down the tube does it extend?

Ans.—The usual arrangement of an oil cup is a cast brass box either circular or rectangular fitted with a cover or lid and having one or more vertical syphon pipes arranged in it and to a height about $\frac{1}{2}$ " off the cover. One or more strands of worsted are taken of several inches length and twisted together at one end and to which a thin piece of copper wire is attached. This wire is bent like a hook and the end with the worsted pushed well down the short syphon tube below the oil in the cup. The other or hook end rests on the edge of the pipe, and thus holds the

worsted in position. The free ends of the worsted are weighted with lead to keep them down in the oil, and the principle of the arrangement is that the fibres of the worsted act as capillary tubes and draw the oil up, and so pass it along to the inside of the syphon tube, whence it slowly drips down and is led to wherever wanted. The worsteds must be taken out of their tubes when engines are not working, otherwise much oil would be wasted. They should be hung by the hook to the edge of box to be ready for their next insertion, and as soon as they show signs of being dirty should be removed and either scalded clean or new ones substituted.

108. Describe a thrust bearing; which of the surfaces wears? Why is there sometimes a number of oil tubes for one thrust bearing?

Ans.—The object of a thrust bearing or block is to take the thrust from the propeller and transmit it to the hull of the vessel and so push this through the water. Their construction, though it varies with different makers, must be very strong and the whole block well secured to the vessel's floors. A good modern construction of block is to have a number of strong cast iron horseshoe shaped collars, each fitted with inserted strips of white metal on both faces, and also having an oil supply to grooves cut in these strips, and each collar having an oil box formed in its top portion. Sometimes these collars are made hollow, and a water service arranged to and from each for the purpose of cooling should they run hot. Along each side of the framing of the block is secured a large diameter rather finely threaded screw, this being held at each end by large nuts, and also carrying at definite intervals thinner nuts, and it is between successive pairs of these that the gaps formed in each leg of the horseshoe collar slip over. The thin nuts each side are then tightened down against this and help to hold it secure, the collar being prevented from moving up by strong tap bolts passing through the end and coming underneath a flange cast on the block. As the thrust comes up the shaft in a forward direction it is the aft surfaces which wear the most, and to take this up if all wear equally the big nuts are slacked off forward and tightened up aft, and so the whole screw and collars are worked aft sufficient to take up the slack. If an individual collar has worn, or we wish to do what is the usual thing, viz., set up so many collars to take the *sternway* thrust, this is done by working the thin nuts to or fro and so moving each collar as desired, but *not* the lot together. Some forms of thrust blocks

have collars simply placed in cast recesses in the framing, being bolted down thereto, and are, of course, fixtures. With these any adjustment for wear must be made by liners inserted between the white metal strip hung upon steady pins and the recess in the collar in which it is placed.

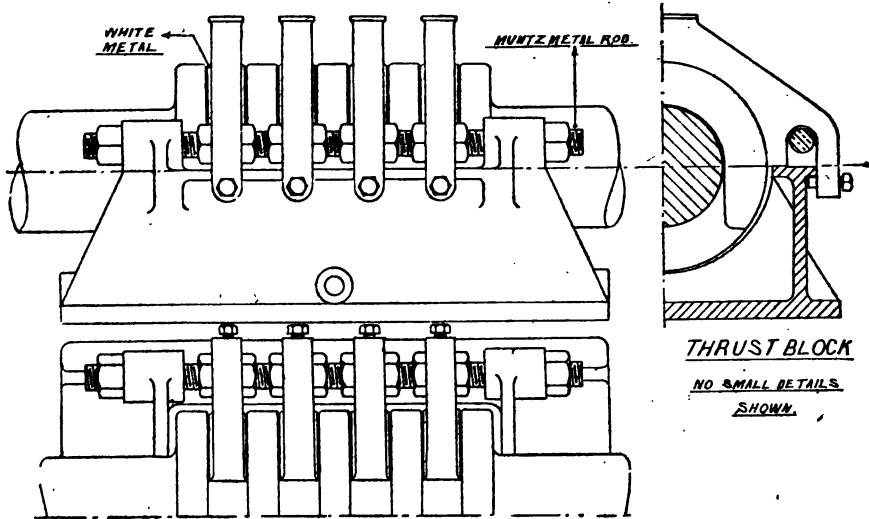


FIG. 49.

108. ALTERNATIVE SETTING.—What is to-day taking the place of an ordinary thrust block? What advantages has it? Why does a thrust heat? To what is a thrust bearing attached? Is it a vital part of the engines?

Ans.—What is called the “Michell” thrust, in which the surface is divided into a number of segmental pivoted blocks contained in a cage fitted to the “block.” The effect of the thrust upon these pivoted blocks causes them to tilt slightly in such a manner as allows the oil to flow in, and the thrust is thus always taken upon oil instead of metal to metal. This system saves about $\frac{9}{10}$ of the friction, is cheaper to make, and allows a shorter bearing. A thrust heats by virtue of the friction between collar and horseshoe, and if allowed to run dry will soon have the white metal melted out. A thrust bearing must be very securely and strongly connected to the floor plates of the vessel, and there is special strengthening worked in by the shipbuilder where the thrust block is to be attached. It is about the most vital part of the equipment of engines, etc., in a vessel.

109. What parts of a screw shaft are generally covered with brass? Why is this necessary? About what thickness is the brass?

Ans.—The parts of the screw or tail end shaft requiring to be covered with brass liners are the two places where the shaft revolves in the lignum vitæ bushing aft, and the stuffing box, etc., in the forward end of stern tube. It is necessary in order to stop the shaft rusting and corroding at these places, as, if allowed to do this, it would soon result in destruction of the wood strips and also the packing. A usual

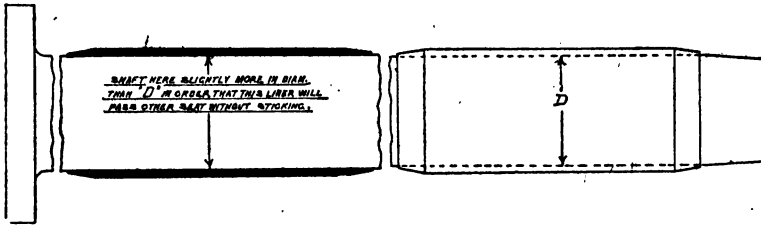


FIG. 50.

thickness of brass is about $\frac{3}{4}$ inch, the liners being prepared the *least* thing less in diameter inside than the shaft, and after being heated internally by gas heaters are slipped over the shaft and shrink themselves tight to it. Afterwards they are pinned in place as well by plain screwed unheaded pins.

109. **ALTERNATIVE SETTING.**—When no brass liners are fitted on a tail end shaft how is the stern tube constructed? And what is done to the shaft itself? Does the brass liner cause any trouble; if so, what?

Ans.—If liners are not fitted the shaft is usually made about $\frac{1}{2}$ " larger in diameter, and runs upon white metal in the stern tube, lubrication being effected by oil fed either by a hand pump periodically or else a gravity supply. Liners cause a bad form of corrosion upon the shaft just at or inside their ends, and which is due to galvanic effect between the brass and iron or steel of the shaft. These are in metallic contact, and, both being acted upon by the dirty water, results in an electrical current being set up which destroys the shaft.

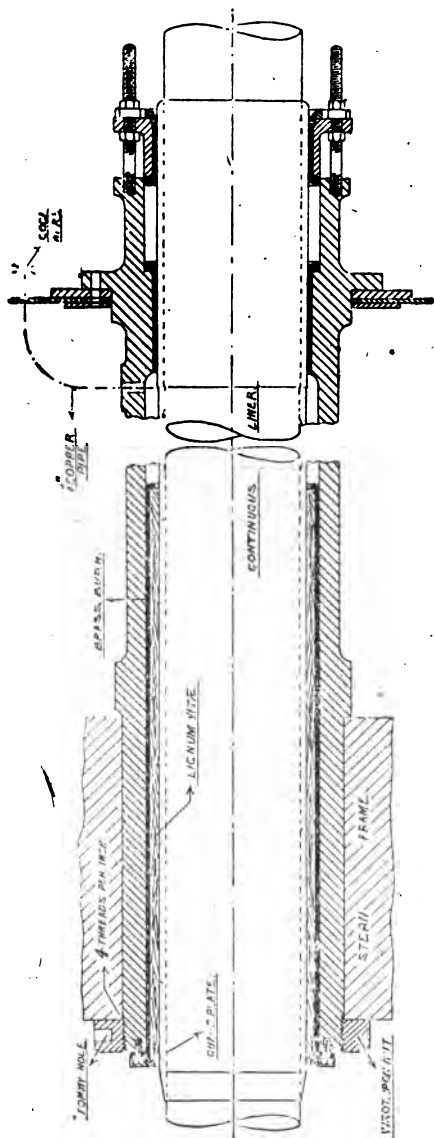


FIG. 51.

- 110. What is the stern tube or screw shaft pipe? Why is a pipe of such a length required? Of what is it made? How is it fixed at each end?**

Ans.—A stern tube consists of a long cast iron pipe of large diameter, having a flange at the forward end for bolting to the after peak bulkhead, and through which the stern tube passes and also through a large boss formed in the stern frame. At the aft end of the tube where it projects through the frame a fine thread is cut and a large cast steel nut secures it firmly in position, there being a collar cast on the stern tube to come butt against the inner face of the stern frame. The tube is fitted with a bush of lignum vitæ at the after end, and at the forward end is made a stuffing box fitted with gland, etc., so that the shaft may revolve watertight or practically so in the stern tube.

The reasons for having a tube of such a length are twofold, firstly, to enable the stuffing box to be brought sufficiently far up the tunnel that it may be readily got at for inspection and the like, and, secondly, by utilising the after peak bulkhead for the forward support it saves having to *especially* erect a structure to carry the inner end of tube.

- 111. What is a lignum vitæ bearing? How is the wood fitted? Where is such a bearing generally used?**

Ans.—A lignum vitæ bearing is usually fitted for the outer bearing of the tail end shaft, and it consists of a cast brass bush or cage turned to fit inside stern tube, and containing a number of strips of lignum vitæ wood cut so that the grain stands outwards. These strips are in some types of bush driven down grooves cast in this latter and all running parallel to the axis, the wood projecting up from the brass a matter of $\frac{3}{8}$ inch to $\frac{1}{2}$ inch, and the space formed between adjacent strips allows sea water to flow up and lubricate the shaft.

Another form of lignum vitæ bearing is to have a plain bush, and into this drive strips of the wood all touching each other, and wedge the whole firmly in place by means of a long, slightly tapering brass key driven down between the last two wooden strips. To allow for lubrication with this plan all the inner edges of the strips are chamfered off.

With both types of bush the inside diameter is finally turned to suit that of the brass liner on the tail end shaft, and the bush placed in position at the after end of the tube, being secured to this by tap bolts passing through the special flange cast as a part of the bush, and to

prevent the wood strips working forward either a collar is cast projecting inwards on the tube or else the brass bush is "bottomed." To

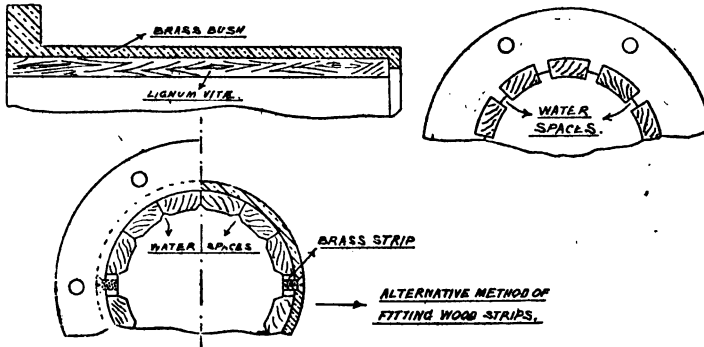


FIG. 52.

prevent the wood working out aft, a "check plate" in halves is secured to the flange of bush, and is turned to a diameter a little more than that of the brass liner on shaft.

112. How is a screw propeller fixed on the shaft? What means are used to prevent its getting loose at sea?

Ans.—The outer or tail end shaft is tapered at about $\frac{3}{4}$ inch to the foot and the propeller boss bored out to suit this. A broad but rather shallow key is sunk and pinned in place on this tapered portion of the shaft, there being a corresponding keyway cut in the boss. This key must be a good fit at the sides, but clear at the top. At the end of the shaft a screw of about $2\frac{1}{2}$ threads per inch is cut to take a wrought iron nut, and the propeller, having been placed upon the taper, is forced hard up by means of this nut, whose thread is cut *left handed* for a right handed propeller, and *vice versa*. To prevent the nut coming off, should it become slackened, a pin tapering a little and split at one end is driven through a hole drilled just aft of the face of the nut. Another plan is to fit a notched plate on to the boss so that one of the cants of the nut fits the notch.

112. ALTERNATIVE SETTING.—If the thread of the propeller nut is of the same "hand" as the screw itself what would likely happen?

Ans.—The propeller when going astern endeavours to come off the taper, and if the nut were of the same hand the revolving would tend

to loosen it, with the result the screw would become slack. With the *opposite* hand any vibrations tending to jar the nut tighten it up.

- 113. Where are sluice valves placed? What large sluice valve is there in almost all screw steamers? From what position should this valve be worked? Why so? What attention should it receive?**

Ans.—Sluice valves are, or ought to be, placed on every watertight bulkhead and on each side of the vessel. On the engine-room and stokehold bulkheads the sluice valves are in the form of wedge like doors fitting down into cast iron frames bolted to the respective bulkheads. The doors are controlled by long screws whose upper end comes up to the top platform and from this point by a suitable lever the screw can be turned, and as it works in a nut securely attached to the door this latter can be closed down from a safe place in the event of any accident occurring below. The door on engine-room bulkhead leads to the tunnel, so in the event of this becoming flooded the door can be closed and the engine-room protected. All sluice valves and watertight doors *should*, at frequent intervals, be operated in order to see that they remain in proper working conditions, otherwise they may refuse to shut when wanted and thus lead to a serious danger.

- 114. With a condensing engine what valves or cocks are on the skin of the ship in the engine room and in the stokehold?**

Ans.—In the engine room of a steamer are situated, on its skin, the main injection and discharge valves. Air pump and bilge discharge valves, inlet for ballast tanks, also the donkey suction and discharge valves as well as the water service cock. In the stokehold are placed the 'blow-down cock to which the scum cock also connects, water service for cooling ashes, donkey boiler blow-down cock and there may be a suction cock for a donkey to work an ash ejector (if one be fitted).

- 115. What are the necessary fittings of a marine boiler?**

Ans.—Including all cocks and valves amongst the "fittings" there are main stop valve, safety valves, main and donkey feed check valves, whistle cock, salinometer cock, test cocks, cocks controlling the water

gauge glass, and if this is arranged for double shut-off working (or even with a "solid" column), then cocks or valves in addition direct on the boiler at the ends of the pipes leading to the gauge column. Also a valve to supply steam to the auxiliary engines, blow-down cock or valve and scum cock, water gauge mounting and a steam pressure gauge. In addition, the funnel, air, casings and uptake, also smoke box doors, fire doors and furnace fronts, bearers, dead plates and bridges.

- 116. With a surface condensing engine what cocks or valves are opened some time before the engine is started so as to be ready for starting whenever the order is given?**

Ans.—With a surface-condensing engine, some time before it has to start, the main and intermediate stop valves should be opened and the throttle valve just eased. Feed check opened, main and bilge discharge valves seen to be free to lift, and the main injection opened and the water service cock also. Next see that all drains from jackets, chests and cylinders, etc., are opened in order to free any accumulated water through condensed steam, and that the suction valves for the feed and bilge pumps as well as their discharge valves are free to lift.

- 117. What is a steam jacket? What cocks are on it? In what engines are jackets most generally used? Do they require to be felted?**

Ans.—A steam jacket is formed by either an outer casing to the cylinder or else having the actual walls of this formed by a "liner" touching the cylinder proper at top and bottom and leaving a space between the two. This space is filled with high temperature steam direct from boiler and the object of this jacketing is to prevent so much condensation inside the cylinder, and this it does by keeping the walls at a temperature *higher* than they would be in an ordinary cylinder unjacketed. Usually the high pressure cylinder of a triple compound is the one having the jacket, but cases are met where all the cylinders have them, and then reducing valves must be employed to bring the pressure down to what is safe for the particular cylinder. Jackets must be fitted with drain cocks to free them of condensed steam and send it either to the hot well or freshwater tank, also a steam inlet cock and sometimes a gauge glass to show if water is present. The outside of the cylinder must be efficiently felted or lagged.

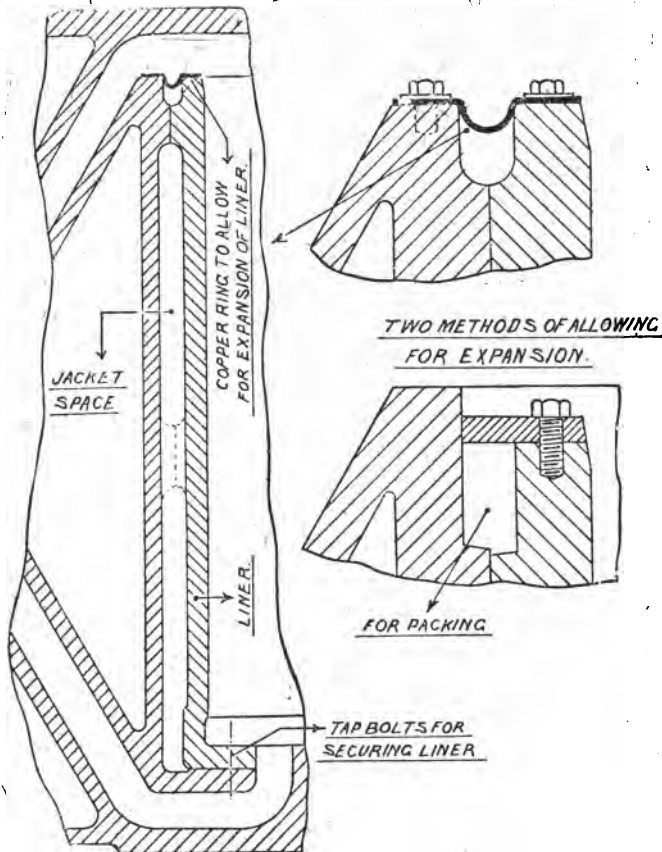


FIG. 53.

- 117. ALTERNATIVE SETTING.**—To prevent condensation in the cylinder what is fitted? What must be attached in order to control the working? Are all the cylinders so treated?

Ans.—(That already given will do).

- 118. What parts of an engine or its fittings should be felted or otherwise protected from radiation?**

Ans.—All the main and auxiliary steam pipes should be well covered with felting, asbestos or cement, likewise all cylinders at the sides, covers and bottom. The boilers should also be covered

efficiently, right round the shell (even inside the seating plates), also the backs, and fronts where possible. and the water gauge pipes as well should be clothed, air casings being fitted to the uptakes and round the funnel. Throttle and intermediate stop valves should be clothed in order to minimise condensation.

119. What are the small cylinders sometimes fitted on the slide valve casing cover of vertical engines? Explain their action. To what are they connected by a pipe? Why?

Ans.—The small cylinders seen above the steam chests contain “balance” pistons fitted to the continuation of the valve spindle. The lower end of the cylinder is open to the pressure existing in the steam

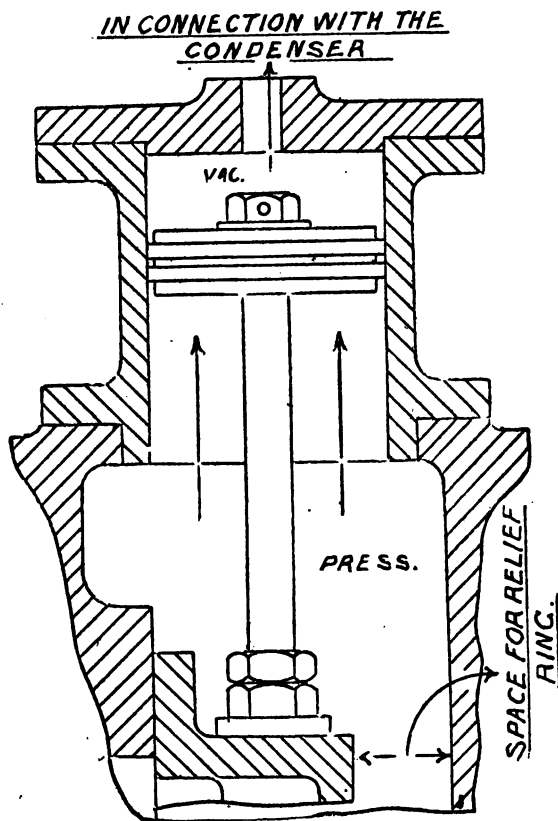


FIG. 54.

chest, while the space *above* the piston is in communication with the condenser, thus there exists a pressure per square inch tending to lift the valve of steam press + vacuum in lbs. The gear is thus eased of so much deadweight, hence the straps, etc., work cooler.

119. ALTERNATIVE SETTING.—What is fitted to take some of the weight of the valve gear off the spindle? What faults have these fittings? How do they operate?

Ans.—(To what is already given add)—The principal fault is the risk of leakage of steam down to the condenser, and if this should occur there will be as many pounds of steam lost every 70 seconds as there are pounds of gross pressure upon the area of the leak.

120. Name the principal pipes in connection with the engines and boilers of a steamer, and state to what the ends of these pipes are connected.

Ans.—The most important pipes about the engines and boilers are the following :—Main steam pipe connecting main stop valve with the intermediate stop and the throttle valves. Eduction or exhaust pipe from low pressure chest to top of condenser. Donkey engine steam supply, connected to steam cock on boiler and the steam chest of the donkey. A steam pipe connecting steam cocks on boiler and the cylinder jacket. Steam pipe connecting whistle cock on boiler to whistle, horn, or siren. Steam for deck purposes, connected to steam cock on boiler and winches, etc., on the deck, and a steam supply to the ballast pump, connected to cock on boiler and to slide chest of pump. Discharge pipes from valve box of large donkey and leading to condenser, overboard and on deck. Main feed pipe connected to discharge valve of feed pump (or air vessel) and to the check valves on boiler. Donkey feed pipe connecting the feed donkey discharge to the donkey check valve on boilers. Donkey suction pipe connected to sea cock on ship's side and the valve box of the pump, with a second pipe coming from hotwell. Feed suction pipes attached to the pump suction and to the hotwell. Main injection pipe attached to main injection valve on ship's side and leading to the suction valve of circulating pump. Main discharge pipe from the condenser to side discharge valve on ship, air pump discharge pipe from hotwell to valve on ship's side, and bilge discharge pipe from the bilge pump delivery valve to discharge valve on ship's side. Blow down and scum pipes connected to their

respective valves on boiler and to the cock on ship's side. Bilge suction pipes attached to bilge pumps and leading from strums or mud boxes at the bilges. Bilge injection pipe coming from the bilge and attached to non-return valve fixed on the main injection pipe. Cylinder drain pipes attached to the different drains and led to the fresh water tank, hotwell, or bilges, also drains from steam pipes and jackets and led to same place. Waste steam pipe from safety valves on boilers to atmosphere, pipe being open ended for the escape of the steam. Water gauge pipes from steam and water cocks (or valves) on the top and lower parts of the boiler and leading to the top and bottom heads of the water gauge mounting. Water service pipe from cock on ship's side to the pipes arranged for cooling bearings, bottom ends, etc., also a pipe from ash cock in stokehold to cock on ship's side. If a starting valve be fitted then a steam pipe is fitted from main steam pipe to the valve chest. A small pipe leading from the boiler to steam gauges placed in the engine room and stokehold.

- 121. Through what cocks or valves, pipes, and chambers does the water pass on its way from the sea inlet rose plate to the water space of the boiler, with a jet condenser?**

Ans.—The various cocks, pipes, etc., the circulating water passes through with a jet condenser are firstly the sea inlet rose plate and main injection valve, then through injection pipe to cock on condenser and up the internal pipe of this, being sprayed from its top. The water then mixes with the steam, and the two lots fall to the bottom of condenser and are taken by the air pump, being sent through the foot, bucket, and head valves of air pump and so into hotwell, from whence a certain quantity is taken by the feed pump through its suction valve (and intermediate piece of piping), being next discharged through delivery valve into feed pipe and so along to and through the check valve into boiler. The balance of the water in the hotwell is sent overboard through the air pump discharge valve.

- 122. Through what cocks or valves, pipes, and chambers does the circulating water of a surface condenser pass?**

Ans.—The water for a surface condenser passes first the rose plate on ship's side and then main injection valve, it then passes through main injection pipe to the suction valve of circulating pump, and passing through this is discharged through its delivery valves and

forced through the condenser tubes and then away by the main discharge pipe up to the discharge valves on ship's side and so overboard. If a centrifugal pump be fitted the water enters its centre and is whirled round by the vanes and discharged from a tangential branch and goes through condenser, etc., as before.

123. Through what cocks or valves, pipes, and chambers does the steam pass from the boiler until it is in the form of water in the hotwell?

Ans.—The following is stated for a triple expansion engine of three cylinders. The steam on issuing from the boiler goes first through main stop valve, main steam pipe, on to the intermediate stop and throttle valves, and thence to the high pressure steam chest. On the high pressure valve moving it is admitted to the high pressure cylinder, in which it does work, and exhausts back through same ports as it entered by into the exhaust cavities of valve and cylinder. Thence by either a pipe or cast passage way it goes to the intermediate pressure chest, and as this valve works it is alternately admitted to and exhausted from that cylinder. By the exhaust cavities it is enabled to pass *via* a pipe or cast passage way into the low pressure chest, and, as before, into and out of that cylinder, being now of a very low pressure, and therefore requiring a greater area of pipe, it passes *via* the large eduction or exhaust pipe down to the top of the condenser, in which it is sent fore and aft by means of an internal deflecting plate. The steam thus comes well into contact with the cold tubes, being thereby condensed, and trickles to the bottom of condenser, and from there, as water, it passes to the air pump, and through this to the hotwell, from whence the feed pumps take it and possibly send it through a feed filter and heater placed in the main feed pipe, and so along to the check valve on boiler, and on passing this it may get to a short directing pipe which sends it to some particular place in the boiler.

Note by Author.—The latter part of the paragraph may be omitted by candidates if they care to, but it is given in order to make the circuit of the water complete.

124. Name the pieces of the engine through which the pressure of the steam is transmitted from the piston to the screw propeller. Name them in the order in which they act.

Ans.—The effort of the steam sets up a certain load on the piston, which is transmitted to the piston rod, and through this to the cross-

head pin, passing thence through the connecting rod to the crank pin. Next by the crank webs to the shaft, and so on to thrust and tunnel shafts, finally getting to the tail end shaft and propeller. It should be mentioned that the effort is transmitted from piece to piece of the shafting by means of couplings and their bolts.

125. What is an air vessel? How does it act? At what parts of an engine or of its fittings are air vessels generally applied?

Ans.—An air vessel is usually a cast iron rather high dome-shaped chamber fitted to the delivery pipe from a forcing pump, and its action is that as the water is forced along the pipe past the bottom of the air vessel it rises within this to a height such that the imprisoned air is compressed to an equal pressure with the water. Then as soon as the discharge from pump ceases this cushioned air expands and reacts upon

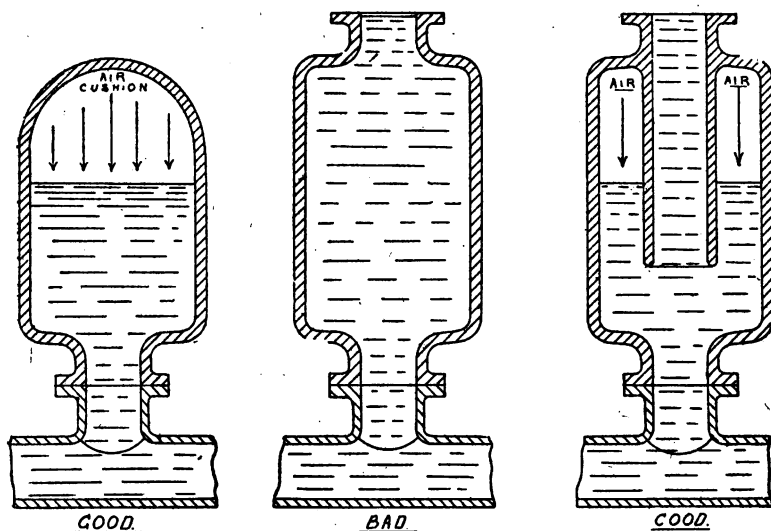


FIG. 55.

the water to such an extent as to force some of it out from the air vessel, and as it can only pass along delivery pipe in the *same* direction as before, it results in the flow being more regular; in fact, a large air vessel enables an almost continuous passage of water. Also, they take up any shock or thud the plunger may impart to the water, and this they do through the act of compressing the air. They should always

be fitted to the upper parts of such as feed pipes or other pump discharges, except such as centrifugal pumps, with which latter there are no shocks.

- 125. ALTERNATIVE SETTING.**—How can the discharge from a single acting pump be made nearly continuous? Suppose a crack took place in the fitting would it work?

Ans.—(To what is already given add)—If a crack came in the upper part of air vessel the air cushion would be reduced and it may be entirely destroyed, and in that event the water would vary in discharge just as though no air vessel had ever been fitted. If crack were very slight all the air might not be expelled for a long time through it, and then the discharge from the pipe would *gradually* become less and less continuous.

- 126. What is the construction of a mud box? Where should mud boxes be placed? Why are they necessary? How should the space be divided by the rose plate, and why?**

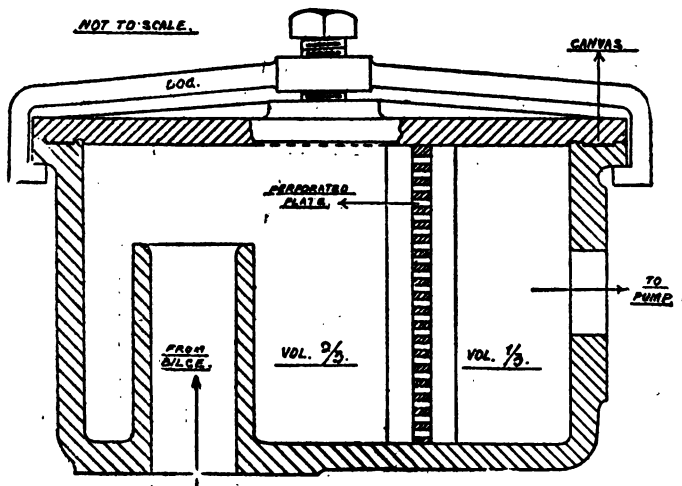


FIG. 56.

Ans.—A mud box is a cast iron chest or box fitted with a removable lid, which is made air tight and kept in its place by a screw and bar. Mud boxes are placed on the suction pipes to bilge pumps, and should be so situated that they are easily opened for cleaning or inspection.

Their shape is usually rectangular, and the inside is divided into two parts by means of a perforated (rose) plate, and through which the water from the bilges must pass, that next the outlet to pump being $\frac{1}{3}$ and the other portion, which is on the bilge side, is $\frac{2}{3}$ the total volume of box. They are required in order to prevent bilge pumps choking with the dirt, small coal, etc., accumulated in the bilges, and so the object of giving more space on the bilge side than the pump side is to allow for a fair silting up of the box before it shall require cleaning out.

126. ALTERNATIVE SETTING.—Should a mud box have an air-tight lid? If no mud box be fitted what would happen?

Ans.—As the mud box is upon the suction side of the pipe it is essential that the *only* opening into it for water, dirt and air should be the main inlet at bottom or side. If air leaked in at cover it would spoil the vacuum the bilge pump is making, and this would refuse duty thereby. If no box is fitted all the small coal, dirt, etc., of the bilges would be drawn up into the pump and gag the valves, score plunger, and generally ruin the whole affair.

127. What is a trunk engine? Why has it fallen into disuse?

Ans.—In a trunk engine the piston rod and crosshead are done away with, their place being taken by a large diameter hollow trunk bolted to the piston and passing through glands and stuffing boxes on

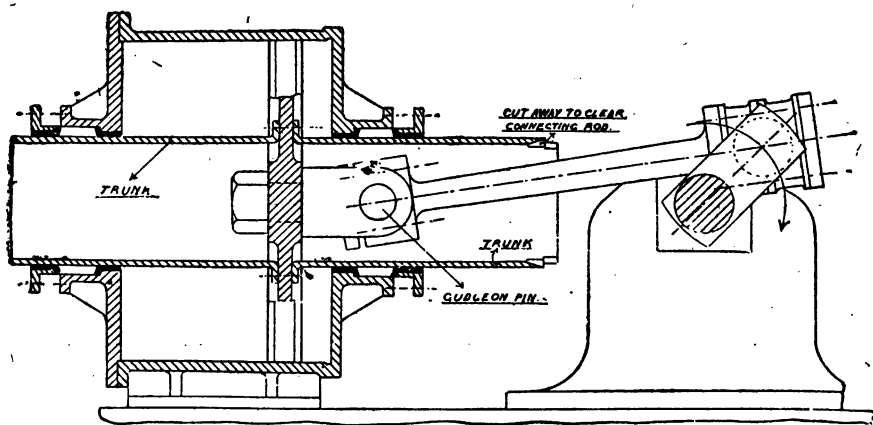


FIG. 57

both ends of the cylinder. The trunk has to be large enough to allow the connecting rod to swing to and fro within it, because the small end of this rod is connected to a large double eye bolted to the piston and whose pin forms what would be the top end gudgeon. The engine is therefore very compact, as the cylinder is brought near to the shaft, but they have fallen into disuse principally through the great cooling effect the large trunks had upon the steam in the cylinder, this causing much condensation, and also at the present day there is not so much need for such a compact engine.

128. What is an oscillating engine? For what steamers are oscillating engines generally adopted? Why? How is the steam conveyed to and from the slide valve casing?

Ans.—An oscillating engine is one where the whole cylinder with valve, chest and part of the valve gear oscillates or rocks backwards and forwards upon hollow trunnions, and the connecting rod is dispensed with, the piston rod being formed at its upper end into a head carrying the brasses embracing the crank pin, and as the crank revolves, the piston and cylinder, etc., turn upon the trunnions. These trunnions lead to a passage way cast round the cylinder to and from the valve chest or chests and having a division in it, one part forms the live steam supply through, say, the outer trunnion; whilst the inner one and that portion of the passage form the exhaust. Oscillating engines occupy much less height than equal powered engines of the ordinary inverted type, and are thus suitable for boats like ferries and other shallow draught vessels having paddle wheels, as its moderate height allows the floats to get a good dip into the water.

129. Of what parts does the valve motion gear of an oscillating engine consist?

Ans.—The valve motion of an oscillating engine usually consists of the "Stephenson" gear having its two eccentrics, straps, etc., and reversing link, but whose block, instead of being directly at the end of valve spindle, is upon a pin placed at the upper part of a slotted quadrant or sector, which sector works vertically between guides formed by the pillars supporting the top framing of the engine. Working in the curved slot of the quadrant is a block at one end of a rocking lever, whose other end takes the valve spindle, and whose fulcrum is made by a bearing coming up from the cylinder itself.

Thus as sector is moved *up* by the eccentric, the valve goes *down*, and *vice versa*, and as the slot is curved to a radius equal to that from the centre of the trunnion when sector is at mid-stroke, it follows that as the cylinder vibrates its motion does not interfere at all with the valve, which is only controlled by what the eccentrics do. The placing of these is now, following the crank, at right angles, *less* the angle for lap and lead. (See plate III.)

The above paragraphs apply equally whether there are two valves, chests and rocking levers (for the purpose of better balancing) or only one.

129. ALTERNATIVE SETTING. — What function does the curved quadrant fulfil in the valve gear of an oscillating engine? How are the sheaves placed with such gear? What is sometimes done to balance the oscillation of the cylinder, etc.?

Ans.—(That already given will do).

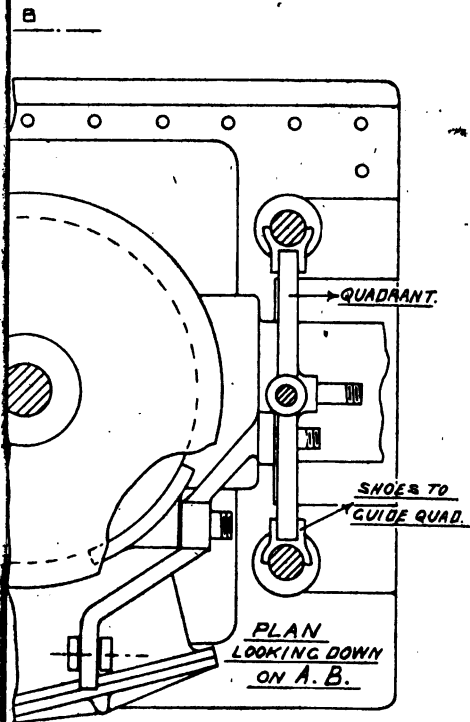
130. For what have geared engines sometimes been used? Of what were the cogs of the large wheel made?

Ans.—In the early days of marine engines the speed of the propeller had to be more than what the engine itself ran at, so a large diameter wheel was placed on the engine shaft and a smaller or pinion wheel upon the screw shaft, resulting in this latter running at a good many more revolutions per minute. The teeth of the large wheel were made of either oak or beech, inserted in properly shaped holes and fastened securely. The smaller wheel was of cast iron with teeth machined to reduce friction and wear.

131. At what part of a screw steamer is the pressure that propels it applied to the hull?

Ans.—The pressure that propels a steamer is called the "thrust" and is applied at the thrust block, which is a very strong casting containing the thrust collars, and this casting is firmly bolted down to either the floors of the ship, or a strong framing coming up from these just aft of the reciprocating engines. But for a turbine, the thrust block is placed forward of the turbo and is not of such massive construction, as the turbine itself takes up the thrust when running at a steady speed.

PLATE III.



To face page 102.

- 132. At what part of a paddle steamer is the pressure that propels it applied to the hull.**

Ans.—With a paddle engine the thrust comes first upon the framework of the wheel and so to its centre, being transmitted to the outer shaft bearings and so on to the paddle beams and framing of the engine, and these being built into the ship it in turn is applied to the hull.

- 133. About how much fuel per indicated horse power per hour is required by modern steam engines, common, compound, and triple expansion?**

Ans.—The coal consumed depends greatly with each class of engine upon their individual efficiency, but taking average values they are, for the common engine, from 3 to 4 lbs. per hour per indicated horse power. A two-stage compound will burn from $1\frac{3}{4}$ to 2 lbs., whilst a three-stage or triple expansion engine consumes from $1\frac{1}{2}$ to about $1\frac{5}{8}$ lbs. per hour per indicated horse power.

- 133. ALTERNATIVE SETTING.—What is about the average consumption with a turbine? Also with oil fuel and with a Diesel engine?**

Ans.—If a turbine is allowed to run at its full (and high) speed the coal consumption is usually a trifle better than with a triple expansion engine, and in the case of geared turbines, where the speed may be very high, tests have shown 1.65 lbs. per hour per shaft horse power. With oil fuel an average consumption is about 1 to $1\frac{1}{4}$ lbs. per hour per indicated horse power, and with Diesel engines it runs about $\frac{1}{2}$ lb. of fuel oil per hour per indicated horse power.

- 134. What is the explanation of the economy of the surface condenser?**

Ans.—With a surface condenser the feed water is sent to the boiler quite fresh, provided the condenser is tight, whereas with the common jet system we have either to keep a continuous blow off or to periodically blow out so much of the boiler water in order to keep its density down. This results in a lot more scale-forming matter coming in with the additional feed, and if the steam pressure be more than about 30 lbs. gauge, large deposits of scale will ensue from the sulphate of

lime turning insoluble. There is also the serious loss of heat in the blow down water as it goes out at the same temperature as the boiler. With the surface condenser the feed is also hotter and so less fuel is required to turn it into steam again.

- 134. ALTERNATIVE SETTING.**—Wherein does the jet condenser appear to less advantage than the surface form. Has the jet any advantage? If so, what is it?

Ans.—(To what is given add)—The only advantage the jet type of condenser has is that the steam *directly* meeting the cooling water is condensed in a quicker and more thorough manner, and so we can sooner attain the desired vacuum.

- 135. What is the construction of a surface condenser? Of what are its tubes made? How are they fixed? How are they kept tight? What is done with a split tube?**

Ans.—Surface condensers are either cast iron chambers formed together with the engine columns, or else they are made independent of the engines, in which case they consist of wrought iron plates worked to form a large diameter cylinder and having cast iron dish-like ends or doors. With either form at each end are fitted brass tube plates and generally at least one brass bearer plate is fitted in the centre of condenser. The brass tubes are put through holes in all these plates and the ends kept tight either by wood ferrules or by cotton packing and glands. The door at the entrance end is formed dish-like and has a division plate half way up it, in order to compel the circulating water as it comes into the lower half of the door, to traverse the bottom nest of tubes; then as the other door has no division plate to it the water can pass up and return by the top nest of tubes to the upper part of the door from whence it goes away overboard at a much higher temperature than what it came in at. It is now the usual practice to send the water through the tubes and let the steam be on their outside. The doors at each end, besides guiding the passage of the water, allow tube ends to be inspected and packed, also new tubes inserted when required.

A split tube can be temporarily repaired by driving in at each end plugs of soft wood which swell with the water, but the tube should be renewed as soon as possible.

136. Where do surface condensers foul? How are they cleaned?

Ans.—Surface condensers foul both inside and outside the tubes, the latter due to oil and grease passing out from the cylinders with the exhaust steam and on the inside due to sand, etc., present in the circulating water, and this trouble is made much worse by mud and the like when navigating shallow channels. To clean the outside of tubes, fill the condenser with fresh water, put therein a fair amount of a strong solution of caustic soda and by means of a steam jet let into condenser boil all this water for some hours and the grease will be removed. Afterwards run the liquor into the bilges and wash condenser out thoroughly before closing up ready for starting. For cleaning the insides of tubes a small wire scratch brush and a hose of high pressure water are as good as anything, but care must be taken not to dislodge any of the tubes

136. ALTERNATIVE SETTING.—Is it an advantage to send exhaust steam through a filter before it enters condenser? Why should condenser tubes get a scale upon their inner surfaces? What care must be exercised when removing this scale?

Ans.—As the grease or oil in the exhaust steam causes condenser tubes to foul it would certainly be an advantage to send the steam through some cleansing process, although there is the risk that this might increase the back pressure. As sea water contains a large percentage of sulphate of lime, as well as magnesian matter, it follows that such will deposit as scale upon the tubes if the temperature becomes anyway high, therefore on this point alone see the condenser never gets "hot." When using scrapers to remove this scale, be careful a tube is not pushed through and out of its stuffing box.

137. What non-conducting substances are employed to prevent radiation, and how are they applied?

Ans.—Steam pipes are usually covered with asbestos rope wound round and round, or asbestos blankets, these being put on in sections and held in place by steel bands. Boilers are also covered with these blankets, or more properly mattresses, but very often on older boilers asbestos or other cement is used. This is liable to crack and crumble off. Cylinders are fitted with either wood lagging over a thin covering of

hair felt, or else a thicker layer of the felt is used and covered with Russian iron sheet, held in place by bands screwed to the cylinder, flanges, etc.

138. In the construction of smoke-box doors and of dry uptakes, what provision is made to lessen the amount of radiation?

Ans.—The smoke-box doors and upper part of a dry uptake are fitted with what is called an air casing, consisting of a light sheet of mild steel held about 3 to 4 inches off the door, etc., by means of a long bolt and a thimble or distance piece. The heat, as it comes through the door, etc., warms the air in this space and thus an upward current is induced preventing so much heat passing out to the stokehold direct.

139. How can the formation of black smoke be prevented? Describe smoke preventing apparatus?

Ans.—As the principal cause for black smoke is an insufficiency of air, the remedy is to admit just the correct amount which can be best brought about by having the fires even and not too thick, and nicely cleaned; also, the spaces between the bars free from cinder and ash. When putting on the "green" coal do so at the front end of furnace rather than to the back, as by so doing the gases which pass off as soon as combustion starts go over the already glowing mass towards the bridge, and thus burn in their proper place.

Whilst it is not to be recommended, yet at times it is necessary to open a small door (the pigeon hole) fitted in the plate below the bridge and so allow air to pass into the combustion chamber, and which, while reducing smoke, may give rise to leaky back ends or even cracked tube plates.

139. ALTERNATIVE SETTING.—Does oil fuel cause as much smoke as coal? What forms or colours does oil fuel smoke take? Why is this?

Ans.—Oil fuel causes at times even denser volumes of black smoke than does coal, and is caused by the same fault, viz., too little air, or the pressure or temperature of the oil not being high enough for more perfect combustion. On the other hand, if the air supply be in excess, then with oil fuel a whitish grey smoke is formed which may become as large in volume as the black, if the air be very much increased.

140. What is meant by "circulation" in a boiler, and what are the results of defective circulation?

Ans.—By circulation is meant the rising of the water as it becomes heated, and thus lighter, from the furnaces, combustion chambers and small tubes, and the colder water sinking to take its place and become heated in turn. This action going on continually sets up what are called the "convection currents," and if their free circulation is impeded it results in the boiler being stiff for steam accompanied by more or less severe priming, and being very liable to heavy corrosion on the bottom parts of furnaces and combustion chambers due to the water lying there very stagnant and becoming dense.

140. **ALTERNATIVE SETTING.**—What do we call the process of water rising in a boiler as it becomes heated and the colder water sinking? If this process is interfered with what results?

Ans.—(That already given will do).

141. What means are sometimes adopted to improve the circulation in a boiler?

Ans.—With a main boiler a special fitting known as Weir's "Hydrokineter" (see fig. 58) can be used, which being fitted to the shell of

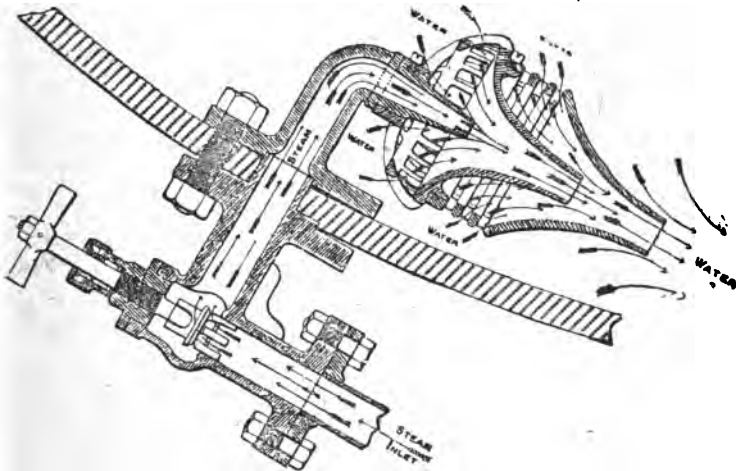


FIG. 58.

the boiler impels a stream of water to be sent from the bottom up amongst the heating surfaces, the hydrokineter using donkey boiler steam at first, but afterwards its own boiler supplies this. Another method is to withdraw a vertical row or two of the small tubes in each box and plugging the holes in the tube plates. This is needed if the boiler has been overtubed, thus choking the spaces the convection currents should have risen in. The easiest, and at the same time one of the best methods, is to send the feed in as hot as possible by delivering it through a heater after it leaves the feed pump.

141. ALTERNATIVE SETTING.—Describe the principle upon which a hydrokineter used to improve boiler circulation works. Is there any other boiler adjunct working on the same lines?

Ans.—The principle upon which the hydrokineter works is that of utilising the high velocity of a steam jet to impart sufficient force to the surrounding water as will enable a current to be produced round the bottom of the boiler. This it does by condensing on meeting the water, and whilst this latter does not get all the velocity of the steam, yet sufficient is utilised to produce a vigorous current. This is the principle upon which an injector for boiler feeding works.

142. By what arrangement is the circulation promoted in a "hay stack" boiler?

Ans.—The circulation in a hay stack boiler is promoted through two factors. First, the small tubes are here water tubes and arranged vertically, connecting what is called the "pan" to the combustion chamber top; thus the water heated in the "pan," which is directly over the four furnaces, at once passes up the vertical tubes and so to the water space above the combustion chamber, and, secondly, "pockets" or circulating passages are built at the outside of the boiler, and being open thereto at the top and bottom they act as downcomers, the water passing *down* the cooler exterior part and *rising* through the heated portion next combustion chamber (fig. 59).

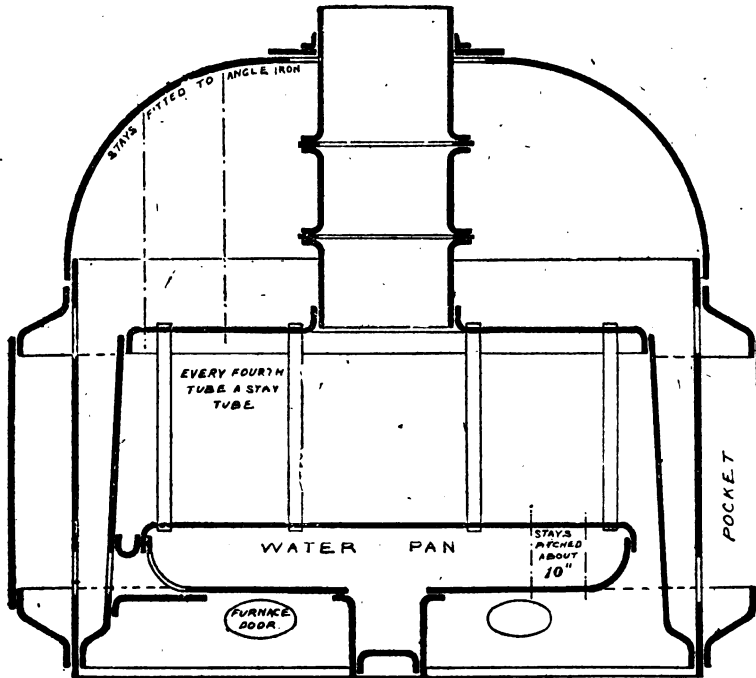


FIG. 59.

143. What is the construction of a feed escape valve; to what is its discharge connected, and how is its loading regulated? Where should the escaping water flow?

Ans.—A feed escape valve consists of a small brass valve fitted between the feed suction and delivery valves. It is kept to its seat by a spring whose compression is brought about by a plate resting upon the spring and also passing over two long screwed pillars. Nuts upon these control the compression of the spring, and thus the pressure at which the relief valve shall open is regulated. This is often about 10 per cent. more than the boiler pressure, though usually the spring is simply compressed sufficiently to keep the valve shut against each normal discharge from the pump. The escape from the valve leads generally to the bilges, though nowadays it is often returned to the hotwell.

The object of a relief valve is to open and so relieve any undue pressure in the pump chamber or feed pipes caused by a valve sticking

or some other nip of the water. When the excess pressure is removed the spring forces the relief valve back on to its seat.

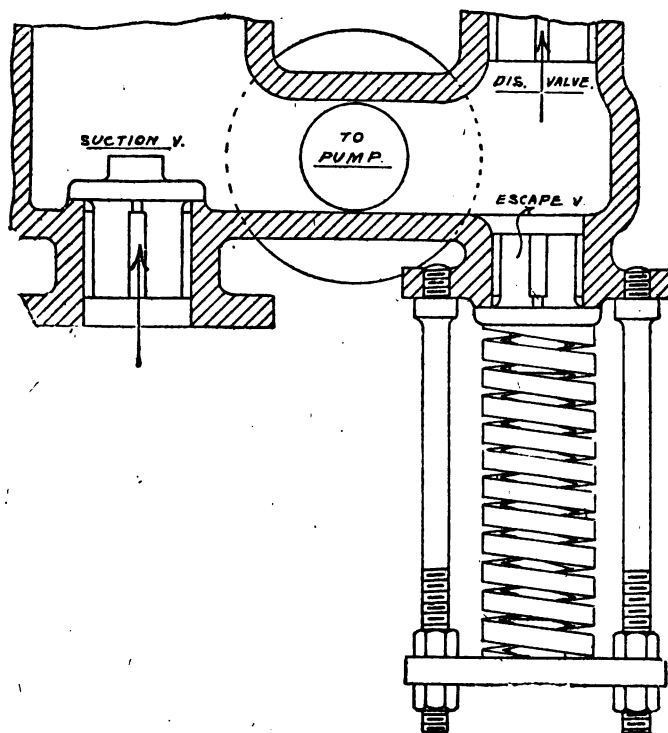


FIG. 60.

143. **ALTERNATIVE SETTING.**—If a feed escape valve requires a greater load how do you obtain it? Where is such a valve placed? Would it not do on the feed pipe? Do you lose the water that escapes when this valve opens?

Ans.—(That already given will do).

144. Describe a ship's side air pump discharge valve. In what respects does it sometimes differ from a common stop valve, and what attention does it require?

Ans.—An air pump discharge valve is of somewhat similar make to a stop valve, except that it is not screw controlled, but has either a

weight or a spring to keep the valve against its seat. It consists of a brass valve and seat contained in a cast iron chamber, fitted with a spigot for passing through the plate and bolted to the ship's side,

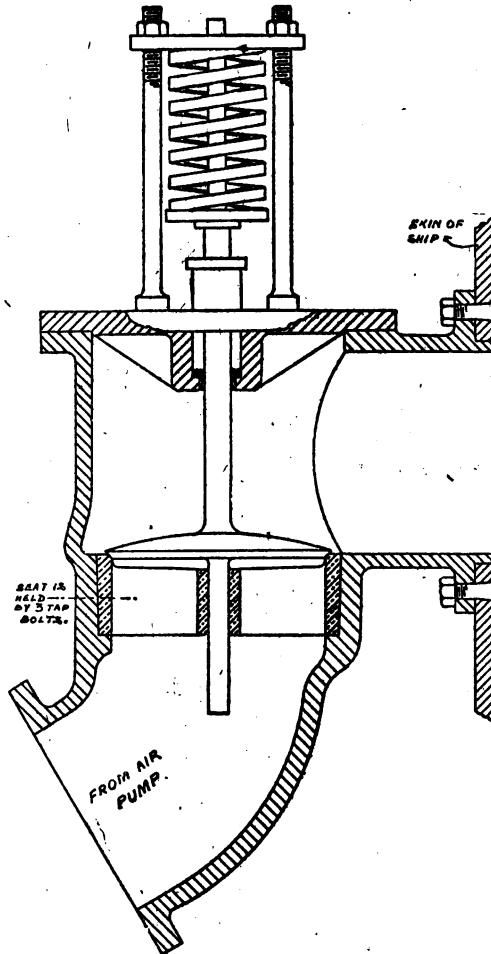


FIG. 61.

usually above the load water level. This is necessary so that no water can leak back through valve and so to the hotwell. Care must be taken to see that this valve is free to lift before starting the engines.

145. When there is no feed escape valve what is the arrangement of the feed valves or cocks?

Ans.—If there is no relief valve the check itself must be such as to eliminate any chance of its being closed tight when engines are started, *i.e.*, it must be unadjustable, and in place of a screwed spindle to regulate the lift of check valve, the cover is cast with a solid stopper of such a depth as will allow the valve to lift $\frac{1}{4}$ of its diameter, but will

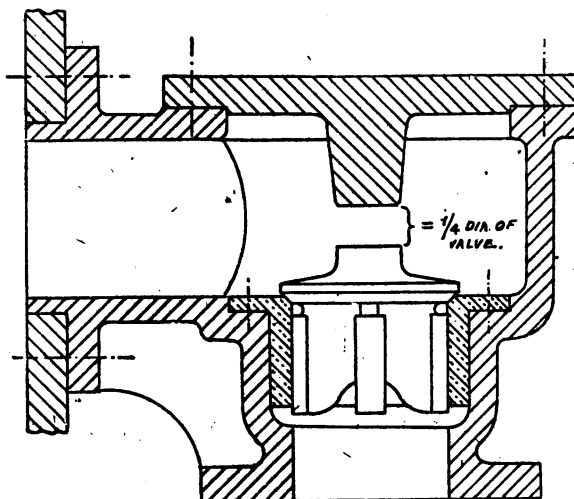


FIG. 62.

entirely prevent any accidental shutting down of the valve. The feed supply must in such cases be regulated either at the special cock on the hotwell or by means of the feed suction and delivery valves themselves.

145. ALTERNATIVE SETTING.—If there is no feed escape valve and the usual form of screw down check is fitted what might easily happen? What is done to prevent this trouble?

Ans.—If the feed check should be screwed tight when the pump is started either the barrel or feed pipe will burst owing to water being practically incompressible, the descending pump ram rapidly rises the pressure to the danger point. (For the other question, answer already given will do.)

146. What is the measure of a horse power? How is indicated horse power ascertained?

Ans.—By the term “horse power” must *not* be understood the amount of power one horse could exert, but it is a standard set up by James Watt whereby outputs of various engines can be measured and compared. It consists of 33,000 foot lbs. of work done in 1 minute, thus a weight of 33,000 lbs. raised 1 foot in 1 minute gives 1 horse-power, or 16,500 lbs. raised 4 feet in 2 minutes would give 1 horse power also, and any product of feet height (or feet moved) $\times$ lbs. so moved and in the time of 1 minute gives the horse power. For indicated horse power (or I.H.P.) we must find the average mean effective pressure per square inch of piston area, and, obtained by means of an indicator diagram, multiply this by twice the stroke in feet of the engine, and also by the revolutions per minute and by the area of piston in square inches, and all this divide by the constant 33,000, or

$$\frac{\text{area in sq. ins.} \times 2 \times \text{stroke in ft.} \times \text{revs. per min.} \times \text{mean effective pressure}}{33,000}$$

= I.H.P.

146. ALTERNATIVE SETTING.—What other horse power have we than “indicated” and “nominal?” Describe how it is found.

Ans.—The third measure is that used with turbines, and called shaft horse power. Turbines cannot be indicated like a reciprocator, and so resource is had to estimating the power from the torsion (torque) on the shaft. It is found by ascertaining the degrees of the torsion angle upon the particular shaft and putting this value into a special formula, on solving which the shaft horse power is given, and is found to be usually about 90% of what the indicated horse power would be. (This latter is based on applying the formula to a reciprocating engine).

147. Has “nominal horse power a fixed meaning? What is the use of this expression? What is generally taken as the measure of one horse power nominal?

Ans.—Nominal horse power has no real or fixed meaning and about its only use is to register a steamer's engines by. The nominal horse power is generally based upon taking the sum of the squares of the respective cylinder diameters, and dividing by a certain constant, which for two-stage compounds is from 28 to 32 (30 as an average) and for a three-

stage, or triple compound, from 18 to 22. Thus, two-stage compound
 $\frac{\text{dia.}^2 \text{ H.P.} + \text{dia.}^2 \text{ L.P.}}{30} = \text{N.H.P.}, \text{ and } \frac{\text{dia.}^2 \text{ H.P.} + \text{dia.}^2 \text{ I.P.} + \text{dia.}^2 \text{ L.P.}}{\text{Say } 21.}$
 = N.H.P.

148.—What is “back pressure” in a cylinder? About how much is it in each of the cylinders in your last steamer? Is excessive cushioning ever a trouble under certain conditions in modern steamers? Say when and why and in which cylinder this occurs.

Ans.—By back pressure is meant that pressure acting on the exhaust side of the piston and in opposition to the live steam and from which it detracts a certain amount of its useful effort. In the high pressure cylinder of a three-stage compound, it may vary from about 60 to 75 lbs. gauge, in the intermediate pressure cylinder from about 4 to 12 lbs. gauge, and in the low pressure from about 2 to 4 lbs. *gross* pressure depending upon the vacuum in the condenser.

Excessive cushioning, which is at the same time excessive back pressure, is always a trouble or loss and tends to check the engine unduly as it turns the top and bottom centres and will be especially noticeable when the engines are moving slowly. It is often caused by an undue amount of “linking up.” Excessive back pressure will be most felt upon the low pressure engine because a rise of, say, 1 lb. on that piston produces much greater effects on account of its large diameter than does 1 lb. more on the intermediate pressure or high pressure. Excessive cushioning due to linking up on the high pressure engine also causes trouble, as it means a less supply of steam to work through the *whole* engine, and thus its collective horse power falls off.

149. What is meant by speed of piston? About how much is the speed of piston in modern marine engines?

Ans.—By speed of piston is meant the number of feet it passes over in one minute and is found from multiplying together twice the stroke in feet by the revolutions per minute. Its amount varies very much, being practically different for every engine, but from about 500 to 900 feet per minute may be taken. Thus stroke 4 feet 9 inches, revolutions 82 per minute, would give $4.75' \times 2 \times 82 = 779$ feet piston speed.

- 150. What is atmospheric pressure? What is its average amount? What instrument tells this amount?**

Ans.—The air surrounding this world exerts a pressure upon all matter and this is what is called "atmospheric pressure," and in amount is 14.75 lbs. per square inch (usually taken in round figures as 15 lbs.) An instrument called a "barometer," from the Greek words *baros* (weight) and *metron* (measure), is used to estimate the pressure, or weight of the atmosphere, above the point of no pressure, *i.e.*, a perfect vacuum.

- 150. ALTERNATIVE SETTING.—Has the atmosphere any weight; in other words, is it capable of exerting pressure? If it does is it always the same amount?**

Ans.—(To what is already given add)—The pressure is always varying a little due to such as air currents, moisture and temperature, and it ranges from about 14 lbs. to 15½ lbs. per square inch.

- 151. What is "gross pressure" or "absolute pressure"? What pressure is it that is shown by the steam gauge?**

Ans.—Gross pressure is the pressure as shown by a steam gauge added to that of the atmosphere, or gross pressure = gauge pressure + 15 lbs. The pressure indicated by a pressure gauge is called the "gauge" pressure and is the gross pressure minus 15 lbs.

- 152. What is meant by "putting off" steam? How is it done? What part of the valve regulates the put off?**

Ans.—By "cutting off" steam is meant that the steam edge of the slide valve, at either top or bottom port, has come up to the steam edge of that port and entirely closed it to live steam admission and so the remainder of the piston stroke must be completed by the expansion of the steam previously admitted. In an ordinary valve the steam lap controls the time of cut off, and speaking generally it is the depth of the face of the slide which governs this important operation.

Note by Author.—Candidates should at this point consult Messrs. Brown's *Slide Valves for Engineers*, as it contains a great deal of useful explanatory matter relating to elementary questions Nos. 152 to 159.

152. **ALTERNATIVE SETTING.**—What do we call the meeting of the steam edges of valve and port? If a valve lacks steam lap will there still be this meeting?

Ans.—When the two edges meet it is called the “cut off” of the steam, and if a valve has steam lap it will occur earlier than where the valve has no such lap, but even in this latter case the cut off will take place only now at the end of each stroke.

153. What is a piston slide valve? Describe its construction. Why are they frequently employed in place of the common slide valve? Have they any disadvantages compared with a common slide valve? If so, name them.

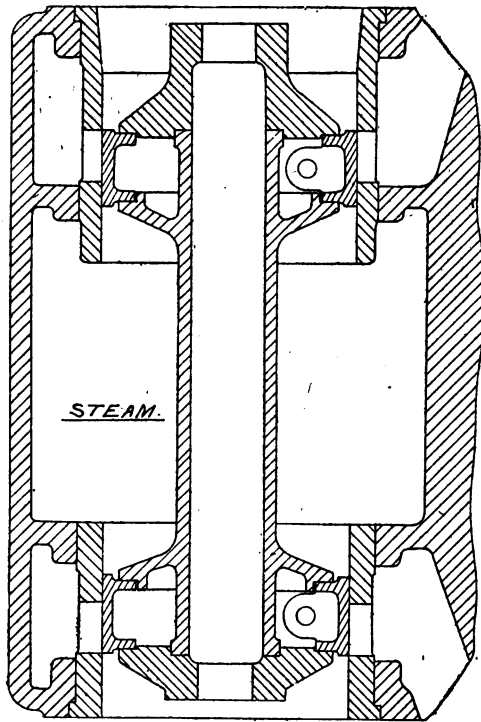


FIG. 63.

Ans.—A piston slide valve consists of two pistons mounted upon a long sleeve piece through which passes the valve spindle, the two pistons

being secured in place by caps and nuts upon the spindle itself. The pistons work in a cylindrical chamber which is a part of the steam chest and having ports diagonally shaped right round the upper and lower parts of this circular chamber. These ports all lead into the respective upper and lower steam passages to the cylinder and the steam is cut off by the circular ring of either "piston" closing the series of ports, exactly as does the ordinary flat type of slide valve close its one large port. Usually steam is admitted between the two pistons, the upper of which is generally a trifle larger than the bottom one, and thus the valve tends to "float" and only exhaust temperature steam comes on the spindle packing, which therefore lasts better. Also with these valves there is a greatly reduced friction, as the pressure of the entering steam is all round them. About their only drawback is sometimes a difficulty to keep the two pistons steamtight, but as very often the pistons are made in the form of spring rings, they can be set out and carefully adjusted and so avoid undue loss.

Such as steam lap and lead are made exactly the same as for a flat valve, but the position of the sheaves on the shaft is, if steam be admitted in the centre of valve, exactly opposite what it is for outside admission.

153. ALTERNATIVE SETTING.—How are piston slide valves kept steam tight? Are both pistons the same size? If the steam chest ports were formed vertically what would result?

Ans.—Piston valves are usually kept tight by means of spring packing rings, which may or may not be fitted with restraining rings to limit the amount they can open. Occasionally one finds each piston being made solid and having a series of grooves turned on its periphery, which grooves soon retain water of condensation, and this makes them tight. Usually the upper piston is slightly larger in diameter than the lower one, and this tends to "float" the valve and gear. If the ports have vertical bars instead of diagonal ones, a series of grooves will soon be worn in the packing rings and tend to destroy their steam tightness.

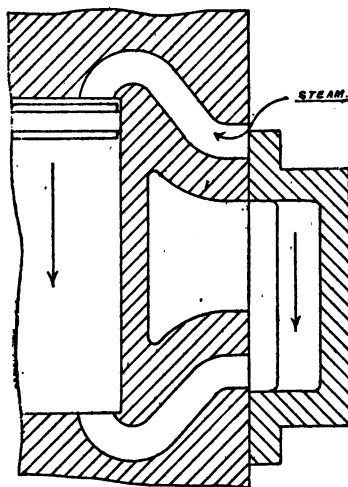
154. What fixes the time of closing the exhaust? After the exhaust is closed and before the port opens for steam, what becomes of the steam that is in the cylinder?

Ans.—The time of exhausting depends upon the particular setting of the sheave, due to the amount of lap and lead, and it is also

governed by whether the valve has exhaust lap or not. As soon as the exhaust is closed, the steam remaining in the cylinder is compressed by the still advancing piston and thus a cushion is formed, which brings the reciprocating masses quietly to rest at the end of each stroke.

155. What is the "lead" of the valve? What is its object?
About what amount is it?

Ans.—"Lead" is the amount either port is open to live steam admission, when the piston is upon the top or bottom centre. The object of this pre-opening or lead is to admit a little live steam to assist cushioning and also to ensure a full pressure ready to start the return



TOP PORT OPEN FOR LEAD

FIG. 64.

stroke. Leads vary a great deal in their amount, being more at the bottom port than the top, but average leads may be taken as from $\frac{1}{16}$ inch at top port of high pressure engine and $\frac{1}{8}$ inch at its bottom port, up to $\frac{1}{4}$ inch top of low pressure engine to as much as $\frac{5}{8}$ inch or even more at the bottom port of this engine. The heavier the engine parts the greater the lead.

- 155. ALTERNATIVE SETTING.**—What may excessive lead produce? What kind of engine requires very little, and which needs a large amount?

Ans.—If the lead is excessive it acts as a too powerful brake upon the engine, slowing it unduly as each centre is approached, and should the engine be moving slowly it may not be able to pass actually over the centre. Quick revolution engines of light parts need only a little lead, but quick running ones with very heavy parts require a good deal.

- 156. What is the "cover" or "lap" of the valve? What is its object? About what proportion of the stroke of the valve is it?**

Ans.—The cover or steam lap is the amount the steam edge of valve overlaps, or is beyond, the steam edge of steam port, when the valve itself is in its mid-position. The object of it is to cut the steam

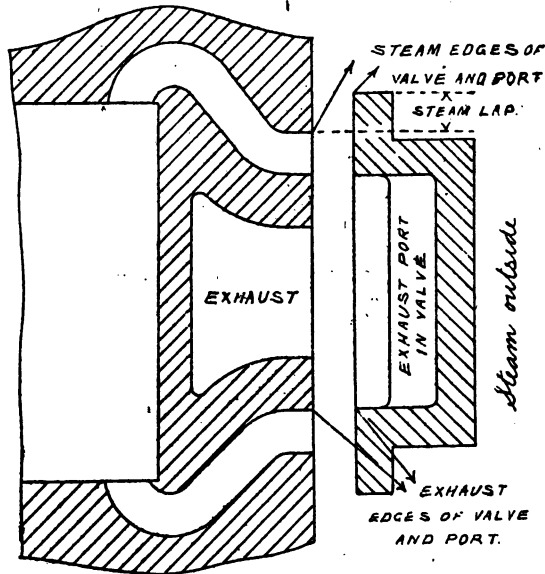
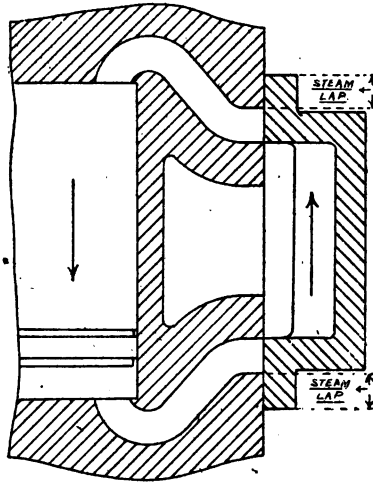


FIG. 65.

off at a part of the engine's stroke before the termination, and thus allow the remainder of the stroke to be completed by the expansion of the steam already in the cylinder. This keeps throughout the engine the economy due to making and using high pressure steam. To cut

off at about half stroke, the lap will be approximately about $\frac{1}{3}$ of the travel of the valve.



VALVE JUST OPENING TOP PORT
TO THE EXHAUST

FIG. 66.

157. What is the "exhaust cover" of a slide valve? What is its effect upon the exhaust and upon cushioning?

Ans.—The exhaust lap or "exhaust cover" is the amount the exhaust edges of the valve overlap the exhaust edges of the steam ports

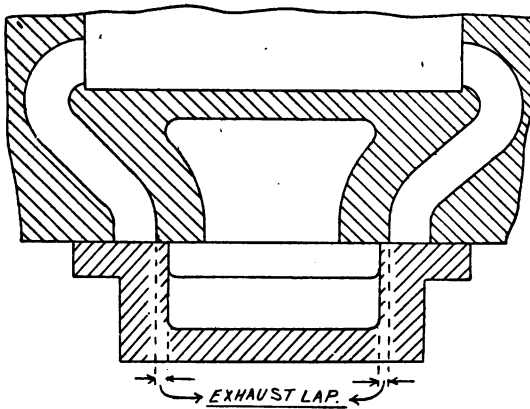


FIG. 67.

or cover the exhaust bars, when the valve is in its mid-position. Its effect upon the exhaust is to make the opening to this later and the closing sooner, hence the effect on the cushioning is to increase this.

157. ALTERNATIVE SETTING.—What else alters the time of exhaust besides the exhaust lap?

Ans.—The position of the sheave. If this is put forward the exhaust opens and closes earlier and cushioning is increased, whereas if the sheave is put back the opposite takes place.

158. What is "minus cover" or "minus lap" on the exhaust? What is its effect upon the exhaust and upon cushioning?

Ans.—"Minus lap," or what would be better called "exhaust lead," is the amount each steam port is open to the exhaust when the valve

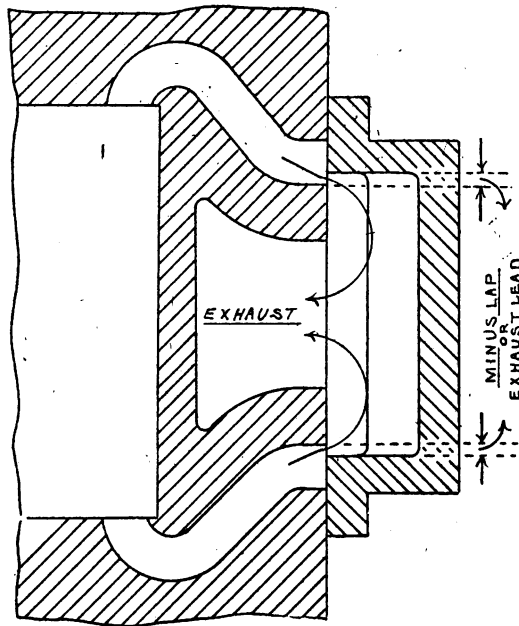


FIG. 68.

is in its mid position. Its effect is to open the exhaust sooner and to close it later, thus reducing the cushioning as a longer time is given for the steam to pass out from the cylinder and hence less remains behind.

158. ALTERNATIVE SETTING.—What do you understand by “exhaust lead”?

Ans.—(That given will do.)

159. What is “cushioning” or “compression” in a steam cylinder? How is it affected by the amount of cover or of minus cover there may be upon the exhaust? How is it affected by the exhaust pressure?

Ans.—Cushioning or compression in a steam cylinder is due to the steam lap of the valve keeping the port shut to the exhaust whilst the piston is nearing the end of its stroke, it having closed the exhaust a short distance from that end. By so doing, the steam imprisoned is brought down to only the clearance volume, and hence its pressure is a good deal higher than was the case at the instant the exhaust closed. This makes the cushion for the reciprocating parts to come quietly to rest with, and the greater the steam lap the more cushioning.

Exhaust lap on the valve increases cushioning, as then the exhaust closes earlier than when no such lap exists, and conversely, minus lap makes cushioning less as now the exhaust closes later.

Strictly, “compression” starts as soon as the exhaust is shut and when the pressure on the back of piston is the same as that on the driving side, cushioning commences and goes on until the port opens for lead.

159. ALTERNATIVE SETTING.—A cushioning curve on a diagram is divisible into two parts; state what they are. Is there any difference between “compression” and “cushioning”?

Ans.—(That already given will do.)

160. What is “mean effective pressure”? How is its amount ascertained?

Ans.—By the term mean effective pressure is meant the average pressure which is actually driving the piston throughout one stroke. The only practical method of obtaining its amount is to take an indicator diagram and divide it into 10 equal parts by means of vertical lines. Then with a scale of equal parts and of the same value as that of the spring used and which must be given with the diagram ($\frac{1}{10}$, $\frac{1}{20}$,

CUT OUT THE SCALE AND MEASURE THE ORDINATES, OR USE A PAIR OF COMPASSES AND TAKE THE MEASUREMENTS FROM THIS SCALE.

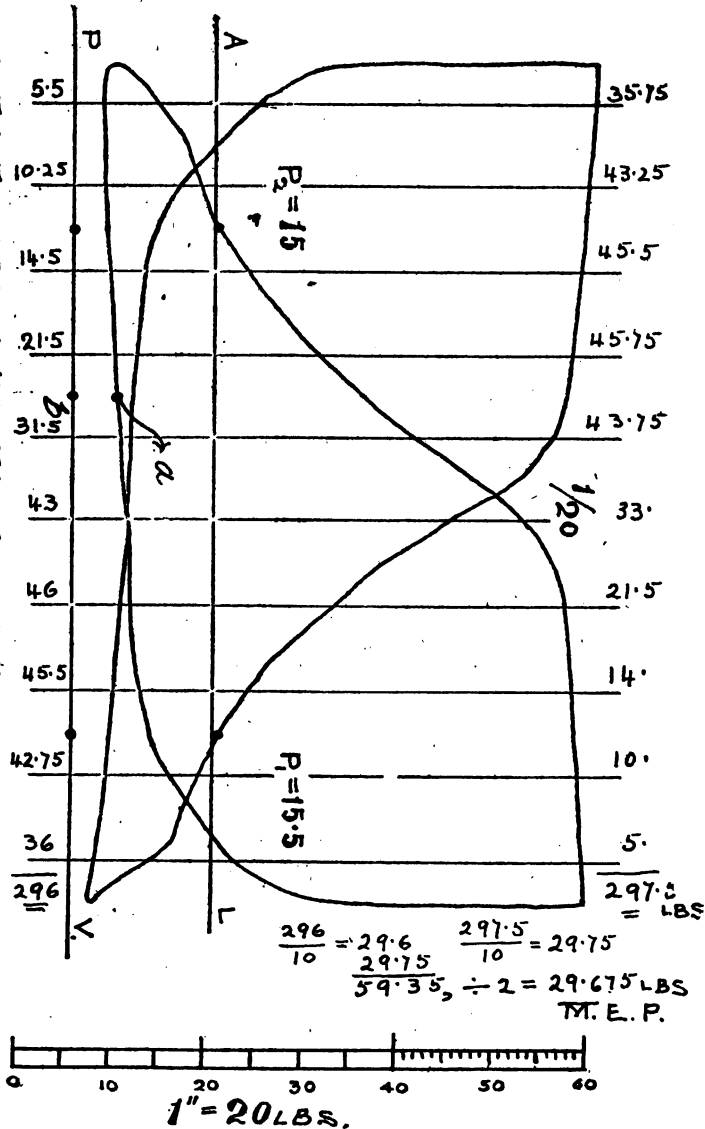


FIG. 69.

$\frac{1}{12}$, etc.) measure *at the centre* of each of these divisions the breadth of the card, that is between its forward and back pressure lines. Add the 10 measurements so found together and divide their sum by 10, the result is the mean effective pressure of that card. If there are cards from the up and down strokes do as before for both of them, and add the separate mean effective pressures together, finally dividing that sum by 2 and so obtaining the mean effective pressure for the complete revolution.

- 160. ALTERNATIVE SETTING.** — Is there any difference between mean pressure and mean effective pressure? If so, state what it is?

Ans.—Yes, there is a difference. By “mean” pressure is simply meant the average or mean of the pressures at various points on the stroke upon the driving side, and it takes no account of the back pressure. Mean *effective* pressure does, however, allow for this, and is the mean forward pressure minus the mean back pressure.

- 161. What is a dial vacuum gauge? What is its construction? For what is it used? About what amount should it show when the engine is working all right? What effect have the variations it indicates on the performance of the engine?**

Ans.—A dial vacuum gauge is an instrument to register the intensity of vacuum in the condenser, or, in other words, to show how much of the atmospheric pressure has been destroyed. Its construction is as follows:—A thin elliptical section tube is bent to form almost a complete circle, and one end is attached to the pipe at the bottom of the gauge leading to condenser. The other end of the elliptical tube is closed and connected by links to gearing which actuates the pointer, and as the vacuum inside the tube becomes greater the atmosphere outside curls the tube round more and more and this movement is transmitted to the pointer, which turns to a fresh position on the dial.

When the engines are in fair working condition and the circulating water is not too warm, the vacuum shown by this gauge should be from 26 inches to 27 inches, showing that from 13 to $13\frac{1}{2}$ lbs. of the atmospheric pressure have been destroyed. If the vacuum varies, then for each inch drop there will be a rise in the absolute pressure of $\frac{1}{2}$ lb., and as we are working *below* the atmosphere this means $\frac{1}{2}$ lb. *less* towards driving the engine.

162. Does the vacuum gauge enable you to tell what pressure there is in the condenser, or must you have recourse to the barometer to arrive at that? How would you ascertain the actual amount of back pressure there is in the condenser?

Ans.—From the vacuum gauge *alone* we cannot tell how much pressure there is in the condenser, and we must consult the barometer. The difference between the reading of this latter instrument and that of the vacuum gauge enables us to find the actual pressure existing in the condenser. Thus suppose barometer to be at 29.8 inches and the gauge to show 25.6 inches vacuum, then 29.8 inches - 25.6 inches = 4.2 inches, and as each inch means $\frac{1}{2}$ lb. pressure there will be $\frac{4.2}{2} = 2.1$ lbs. absolute in the condenser.

163. What is a barometer? What is its construction? Is a barometer sometimes used instead of a vacuum gauge? In what respect does the weather barometer differ from the vacuum gauge barometer?

Ans.—A barometer is an instrument for showing the pressure, and variations in the pressure, of the atmosphere. It consists of a glass tube about 33 inches long, sealed at the top end, but open at the lower. This tube is inverted and carefully filled with mercury, allowing all the air to be driven out, by holding the tube slanting whilst filling it. Then place a finger over the open end and invert the whole into a cup of mercury, remove the finger and the mercury in the tube will drop to about 30 inches. The tube should be about $\frac{1}{4}$ inch or $\frac{3}{8}$ inch in diameter, and as the atmosphere presses upon the mercury in the cup, and an almost perfect vacuum exists between the top of tube and mercury therein, it follows that as the atmospheric pressure gets greater the mercury is forced *higher* up the tube, and *vice versa*. To show these variations a scale of equal parts is placed alongside the upper part of tube, and, being graded to show inches and decimals, we note where the level of the mercury has risen to and against that place we read off the inches, etc., from the scale. There are slight variations in detail in some forms of mercurial barometers but the above is the principle of all.

The barometer is occasionally used in connection with condensers on land for ascertaining the vacuum, and it is carried out by leaving the upper end of the tube open and connecting it with the vacuum

space in the condenser. The height the mercury now rises to shows the amount of the atmospheric pressure destroyed, that is, the vacuum

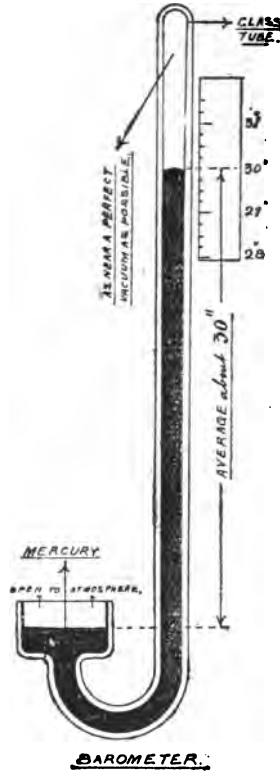


FIG. 70.

in the condenser. The principal difference, therefore, between the vacuum gauge barometer and the weather barometer is that the top end of tube is open with the former and closed in the latter.

164. The common vacuum gauge and the common steam gauge, in which of them are the graduations marked from the atmospheric pressure? Does either of them tell what is the true actual pressure in the boiler or the condenser?

Ans.—Both steam and vacuum gauges are graded from atmospheric pressure, the former marked in lbs. *above* the atmosphere, the latter in

either inches or lbs. *below*. Neither steam nor vacuum gauge indicates the real pressure existing in boiler or condenser, and to obtain this it is necessary to add 15 lbs. to the gauge reading of the steam one and so get the absolute or gross boiler pressure, and the difference between the readings of the weather barometer and the vacuum gauge gives the actual pressure in the condenser.

- 164. ALTERNATIVE SETTING.**—In grading pressure and vacuum gauges do we start at the zero of pressure? If not, where from? How is the true pressure ascertained?

Ans.—(That already given will do).

- 165. Do steam and vacuum gauges vary with the variations of the weather barometer? When the weather barometer varies from 29 to 31, how much will the vacuum gauge vary, and how will that affect the working of the engine? Why?**

Ans.—Both steam and vacuum gauges show variation dependent upon the height of the weather barometer, thus if the barometer be at say, 29 inches and the steam gauge showed 175 lbs., then the gross pressure would be $175 + \frac{29}{2} = 189.5$ lbs. If, now, the barometer rises to 31 inches, then owing to the higher atmospheric pressure the boiler would not generate the steam as high as 175 lbs., it being, in fact, only 174 lbs., as the atmospheric pressure is 1 lb. more, but the gross pressure of the steam is the same as before, or $174 + \frac{31}{2} = 189.5$ lbs. The effect upon the vacuum gauge by a rise in the barometer from 29 inches to 31 inches (*i.e.*, 1 lb.) will be to show 2 inches more vacuum because the greater atmospheric pressure can force the mercury column higher for a given degree of exhaustion above the top of the column. Or with the usual type of vacuum gauge the greater external pressure will collapse the tube still further, and so give a greater reading on the dial.

The working of the engine will not be affected by this, because whilst the back pressure line of the low pressure indicator card comes lower, in order to show the greater working vacuum, still the gauge pressure on the low pressure is also down by the same amount (1 lb.) and the engine runs as before.

- 166. Vacuum is generally stated as so many inches. What is meant by, say, 20 inches vacuum? What does that tell us about the absolute pressure of the vapour then in the condenser?**

Ans.—Vacuum is usually stated in inches because it is the custom to graduate and read off the weather barometer in that fashion, and though the latter denotes pressure existing and the former the amount of pressure destroyed, yet custom has dictated that both be expressed in the same unit owing to the old vacuum gauges having been mercurial columns. By 20 inches of vacuum is meant really that a pressure corresponding to 20 inches out of the average 30 inches of the barometric equivalent to the 15 lbs. has been destroyed, hence every 2 inches of barometric height equals 1 lb. and so $\frac{20}{2} = 10$ lbs. of the atmospheric pressure is absent, hence 15 lbs. - 10 lbs. gives 5 lbs. as the actual pressure then in the condenser.

- 167. From what depth will a pump draw water? Is there any limit? Why?**

Ans.—The depth a pump will draw water practically is only about 26 to 28 feet, as it depends upon the degree of vacuum the pump can make, the pressure of the atmosphere and the specific gravity of the liquid to lift and as about the best vacuum a so-called suction pump can produce is 25 inches, we have $\frac{25}{2} = 12.5$ lbs. of the atmosphere is destroyed. As a column of fresh water of 34 feet height balances the perfect vacuum of 15 lbs. or 30 inches, we have $15 : 12.5 :: 34 \text{ feet} = 28.3 \text{ feet}$ as about the maximum a pump can lift water. The limit is therefore really the quality of the vacuum in the pump. Hot water will not lift as high as cold, because the vapour rising from it tends to destroy the vacuum.

- 167. ALTERNATIVE SETTING.—Will a pump draw from a depth of 40 feet? Explain why the particular limit cannot be exceeded, and say what that limit of depth is in feet.**

Ans.—(That already given will do).

168. What is vacuum? Can vacuum move a piston? When the temperature of the water in the condenser is 212° Fahrenheit, what is the greatest degree of vacuum there can then be in the condenser?

Ans.—Vacuum is a closed space entirely void of any pressure. A perfect vacuum is a theoretical state and never exists absolutely, though in some scientific instruments it has been almost attained. Vacuum itself cannot move a piston, *but* by virtue of there being a vacuum on one side of this and, say, the atmospheric or any other pressure upon the opposite side, then a piston will move in the direction of the vacuous side.

If the water in condenser reached 212° F. there would be no vacuum, because water boils at this temperature under atmospheric pressure, and supposing there *had been* a vacuum in the condenser hitherto of, say, 25 inches, or an absolute pressure of 15 lbs. $-\frac{25}{2} = 2.5$ lbs., we know that water boils when under this pressure at a temperature of about 128° F. and so the condenser would fill with steam vapour under a pressure, long before 212° F. was reached.

168. **ALTERNATIVE SETTING.**—What name is given to a space wherein no pressure exists? Is it any use forming a space in which the pressure is considerably lower than the atmosphere?

Ans.—(That already given will do).

169. What is a thermometer? What is its construction? What is the property of matter that is the principle of its construction? What temperatures are regularly noted by careful engineers?

Ans.—A thermometer is an instrument of glass for indicating the sensible heat or temperature of a body. This it does by being brought into contact with the mass whose temperature we wish to ascertain. In construction a thermometer is a glass tube usually of about $\frac{3}{16}$ -inch to $\frac{1}{4}$ -inch diameter, and having a bore of about $\frac{1}{32}$ inch or less through it, formed with a bulb at the bottom for the mercury or alcohol to be in, as well as a short way up the tube. The upper end of the tube is sealed and a nearly perfect vacuum exists in this upper portion. On bringing the tube near a source of heat, both

glass and mercury (or alcohol) expand, the two latter more than does the glass and thus a certain amount of the fluid in the bulb becomes forced up the very fine bore and the height to which it will rise depends upon the *difference* in the expansions of the glass and the fluid itself. The higher the temperature of the body, the higher the fluid rises and

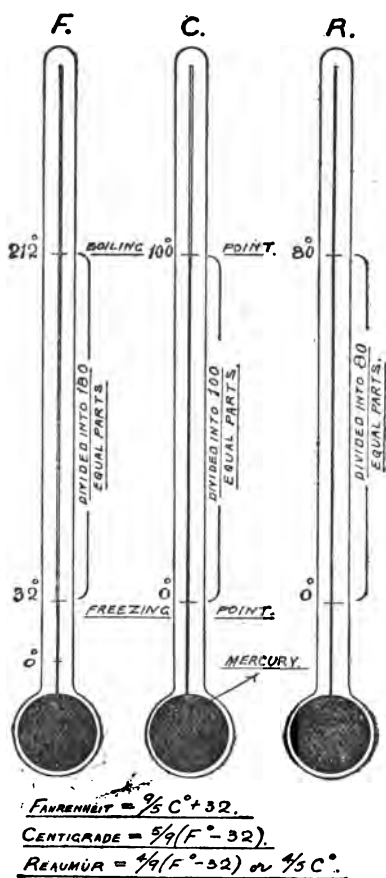


FIG. 71.

the tube, etc., being mounted on a wood or iron back, graduated in degrees of temperature, we can read off on this scale at the height the fluid rises to, what the temperature is at that moment. The need for a relatively large bulb containing the mercury, and the very fine bore of the tube opening into the bulb, is that the trifling actual expansion

of the bulb full of mercury may make a noticeable rise in the thermometer column and *vice versa*, as its principle is the one of expansion by heat and contraction by cold. Thermometers are graded by immersing in melting ice and the level the mercury shrinks to being marked 32° F., 0° C., and 0° R., and to get the boiling points, it is immersed in boiling water under the atmospheric pressure and the height the mercury rises to being marked 212° F.; 100° C., or 80° R., and the space between the above freezing and boiling points is divided into 180 equal degrees for F., 100° for C., or 80° for R., where F. stands for Fahrenheit, C. for Centigrade (or Celsius) and R. for Reaumur.

A good engineer notes always the temperatures of the following, viz.:—Sea inlet to condenser (about 50° to 60°), the discharge water (about 100° to 110°) and the feed temperature.

170. What is the temperature of (1) melting ice; (2) boiling water; (3) steam about 60 lbs. pressure by the steam gauge; (4) steam about 100 lbs.; (5) steam about 150 lbs.; (6) smoke in the funnel; (7) water in the hotwell.

Ans.—Melting ice has a temp. of	-	-	-	32° F.	0° C.
Boiling fresh water	„	(under atmos. press.)		212° F.	100° C.
Steam 60 lbs. gauge press	-	-	-	307.5° F.	153° C.
„ 100 lbs.	„	-	-	338° F.	170° C.
„ 150 lbs.	„	-	-	366.5° F.	186° C.
Smoke in funnel, from 600° to 700° F.,					
(best about).	-	-	-	630° F.	332° C.
Water in hotwell, from 110° to 140° F.,					
(best about).	-	-	-	120° F.	48.9° C.

Note by Author.—The centigrade temperatures need not be given by candidates unless they are definitely asked for. The rule for conversion of F. into C. should, however, be remembered by all, it is $C^{\circ} = \frac{5}{9} (F^{\circ} - 32)$.

171. What is meant by the “conduction” of heat? Give examples of it in the boiler and in the engine.

Ans.—Conduction is the carrying, conveying or conducting of heat along or through metals, such as a rod of iron inserted at one end in a fire becomes hot at the other end by the heat being carried through the particles of the bar itself. In a boiler the heat of the furnace is

"conducted" through the furnace tube to the water side and so to the water. Also the heat inside the boiler is conducted through the shell plates to the outside. In the engines the heat inside the steam pipes or the cylinders passes by conduction through the copper, wrought iron, or cast iron and so away to the surrounding air.

172. What is meant by the "convection" of heat? Give examples of it in the boiler and in the engine.

Ans.—By convection is meant the carrying or transfer of heat from one place to another through a liquid or gaseous medium and in any direction, though principally vertically. In the boiler the water is heated more or less uniformly by "convection" currents which are formed originally by the gradual heating of the water and it thus, becoming lighter than the surrounding mass, rises and at the same time the colder water rushes in to be in turn warmed. Then as soon as steam in bubbles is formed, these rush upwards and so help the convection stream which soon attains a good velocity, and it is by this that the whole mass of water becomes hot and the steam passes to the steam space. In the engines the heat is convected or carried by the steam in the steam pipes and cylinders.

173. What is meant by "radiation" of heat? Give examples of it in the boiler and in the engine.

Ans.—By radiation of heat is meant the passing off in straight lines or in a radiant manner the heat from such as the fire in the furnace tube, or from the cylinders, boilers and in fact any hot body. The heat, after it has been *radiated* from the fuel, is *conducted* through the plates and *convected* through the water, warming the whole boiler which again radiates some of this heat to the atmosphere. Radiant heat is well typified by the heat from the smoke box in the stokehold.

174. Which is convection, which is radiation, and which is conduction in the following cases:—(1) Heat from the glowing fuel to the furnace crown? (2) Heat passing from one side of the furnace crown plate to the other? (3) Heat passing from the steam pipes in the engine room? (4) The heat of evaporation?

Ans.—The heat passing from the fuel as it burns is radiant heat and being received by the fire side of the crown is conducted through

this plate and warms the water on the water side, which then rises and flows to the water level, thus allowing the colder water to come in and be in turn heated. This action is called convection. The heat necessary for evaporation in the boiler is convection.

175. What are the effective heating surfaces of a marine boiler?

Ans.—In a marine boiler there are several heating surfaces, some being more efficient than others. Coming first as the most “effective” is any surface, horizontal or practically so, hence the upper half of the furnace tubes are the best, next in order are the plates of the combustion chamber, especially if it has a sloping back, but as a rule vertical surfaces are not at all good for free evaporation, but seeing the gases complete their combustion in this chamber, a good deal of the steam formed must be credited to it. Lastly, the small or smoke tubes are the poorest surfaces, as usually a large percentage of their internal area is covered by soot, which is one of the finest *non-conductors* of heat known, hence the desirability of always keeping these tubes as clean as ever possible.

175. ALTERNATIVE SETTING.—Some heating surfaces in a boiler are better or more “effective” than others. State which they are and why.

Ans.—(That already given will do).

176. What parts of a marine engine are exposed to danger when the temperature is below freezing point?

Ans.—As water expands when it is on the point of freezing, any parts of the engine where water can remain without room for its expansion and become frozen are liable to be burst. The principal places, therefore, are small steam pipes, feed pipes, cylinders, condensers, feed, bilge, air and circulating pumps, together with such as ballast and bilge pumps and any of the pipes in connection with these. They should all be most efficiently drained, and a fire kept burning or other means taken to endeavour to prevent the temperature of the engine room dropping below 32° F.

It must, of course, be borne in mind that the above really supposes the engines are going to be laid idle for some time, so that the engine room loses its natural warmth.

176. ALTERNATIVE SETTING.—Why should engine parts containing water be liable to fracture in very cold weather, and what is the peculiar feature water possesses which accounts for this?

Ans.—(When answering draw attention to the *expansion* of water, as it falls from 39·1° to 32° F., and if in a filled space how this expansion or swelling causes a burst.)

177. What precautions are necessary in cold climates when the temperature is below freezing point?

Ans.—This is practically answered in what was written to Q. 176, but in addition there may be stated to keep, if steam be on the donkey boiler, the winches moving slowly, and also to get a steam heater or two into the engine room. By working the winches, the deck pipes are not so liable to freeze up, as anything like water in motion does not freeze so quickly as the same water when quiet, but of course if the deck pipes can be thoroughly drained of all water that is the best.

178. State as many ways as you can by which a boiler might not get its full feed. A boiler, or one of a set of boilers, gets short of water although the feed valve is open its proper amount, to what causes might this be due?

Ans.—The following are all possible causes as to why a boiler does not get its correct feed. The air pump valves broken, and thus the right amount is not sent into hotwell, the feed valves may be broken or the escape valve stuck off its seat and thus allowing the feed to pass back to hotwell, or to the bilges. Through broken feed pipes or leaky joints on the same, or if there are two or more boilers all supplied off the same feed pipe, a check valve on one of them may be broken and so this obtains more than its share of the feed, and the others of course only a reduced amount. Or possibly the feed pump gland leaks badly, or there is a defect in the casting of the chest of this pump.

179. Of what are furnace bars generally made? About what thickness are they at the top? About what space is between them? Are the bars put further apart for Newcastle than for Welsh coal?

Ans.—In the Mercantile Marine boilers, the fire bars are of cast

iron, but for Navy boilers steel is used. Cast iron bars are about $\frac{7}{8}$ inch to 1 inch in thickness at the top and taper to about $\frac{5}{8}$ inch or $\frac{3}{4}$ inch at the bottom. They have distance pieces cast on them at both ends, and if long, in the middle of the length as well, of about $\frac{1}{4}$ inch thick so that when two bars are laid side by side, a space of $\frac{1}{2}$ inch exists between them, for air to pass up through, and ashes to drop down to the ashpit.

They should theoretically be placed a trifle wider apart for Welsh coal as this requires a little more air than does Newcastle, but as the former is a more friable coal and easily breaks up, sometimes it is found necessary to bring the bars actually a trifle closer together.

- 179. ALTERNATIVE SETTING.**—About how much more air does Welsh coal require per lb. than Newcastle? With natural draught how could you get this up to the fuel? Is this done, and if not why not?

Ans.—About 7% more air is needed for Welsh coal, although the actual amount varies a little with the particular composition of the coal, but being richer in carbon than Newcastle it needs more air. (Then follow on with what is already given.)

- 180. Which burns faster, Newcastle coal or Welsh coal? Which is the flaming coal? Which makes more smoke?**

Ans.—The Newcastle coal burns quicker than Welsh, and it is also a more flaming fuel and causes a good deal of smoke. With Welsh coal the heat is much more local, hence it is therefore not such a flaming fuel and smoke is very much less.

When burning Welsh coal one must be careful not to roughly use the fires, or a great amount of the fuel will find its way through the bars.

- 181. About how many tons of steam coal will be burned per day in four furnaces each 3' 0" wide, and of about the usual length? On what grounds do you say so?**

Ans.—Taking the average length of fire bars at 6 feet 0 inches, and on each square foot of grate there being consumed, say, 16 lbs. of coal

per hour, we have 4 furnaces $\times$ 3 feet $\times$ 6 feet $\times$ 16 lbs. $\times$ 24 hours
 $= 27648$ lbs. or $\frac{27648}{2240} = 12.34$ tons per day and from which a handy rule can be formed, which is, "the coal consumption in tons per day is at the rate of 1 ton per foot diameter of furnace," thus 4 furnaces $\times$ 3 feet $= 12$ tons.

The grounds for stating as above are the average consumption of about 16 lbs. per hour per square foot of grate, and bars of 3 feet $\times$ 6 feet, and, of course, natural draught.

181. ALTERNATIVE SETTING.—About how much oil fuel is burnt per hour per indicated horse power with a modern oil burning installation? Why is less consumed for an equal power than coal? What are the chief advantages of oil fuel?

Ans.—With an installation of the Meyer-Smith system (as shown in plate IV.) the consumption is about 1.24 lbs. per hour per indicated horse power, but varies with the calorific power of the fuel (both coal and oil.) Taking oil at an average of 19,000 British thermal units, and average coal at 14,800 British thermal units per lb., and a coal consumption of 1.6 lbs. per hour per indicated horse power we have 19,000 : 14,800 :: 1.6 = 1.24 lbs. of oil fuel per hour per indicated horse power. The chief benefits by using oil fuel are, less bunker space, cleaner stokehold, greater thermal units per lb., less firemen, better control over fires, greater distance run without rebunkering, and cleaner boilers.

The reason why less oil is used is owing to its greater number of thermal units per lb. This enables it to evaporate more water per lb. of the fuel, so that if the engines only require the *same* amount of steam in both cases, this will be produced for *less* oil fuel used.

Plate IV. shows the well-known Meyer-Smith system of oil burning and the following is a brief description. The pump draws oil through the suction filter which has a medium gauze wire strainer, and passes it to the delivery heater at from 50 to 70 lbs. pressure. In passing through this heater it is raised to as much as 180° to 240° F. according to the viscosity of the particular brand of fuel oil. Next the oil is passed through delivery filter which has a fine mesh strainer and is here thoroughly filtered before passing to burners.

When lighting up, the oil is bye-passed back to the suction side of pump, instead of to burners, until desired temperature is reached.

PLATE IV.

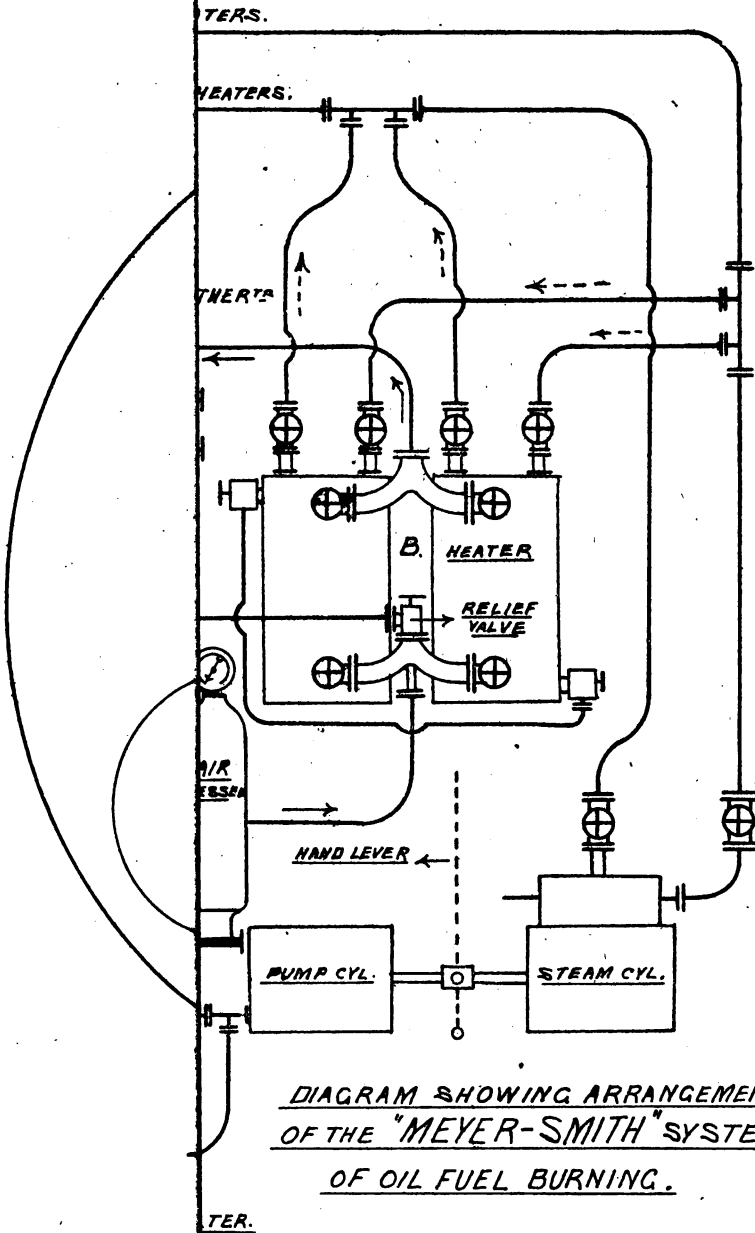
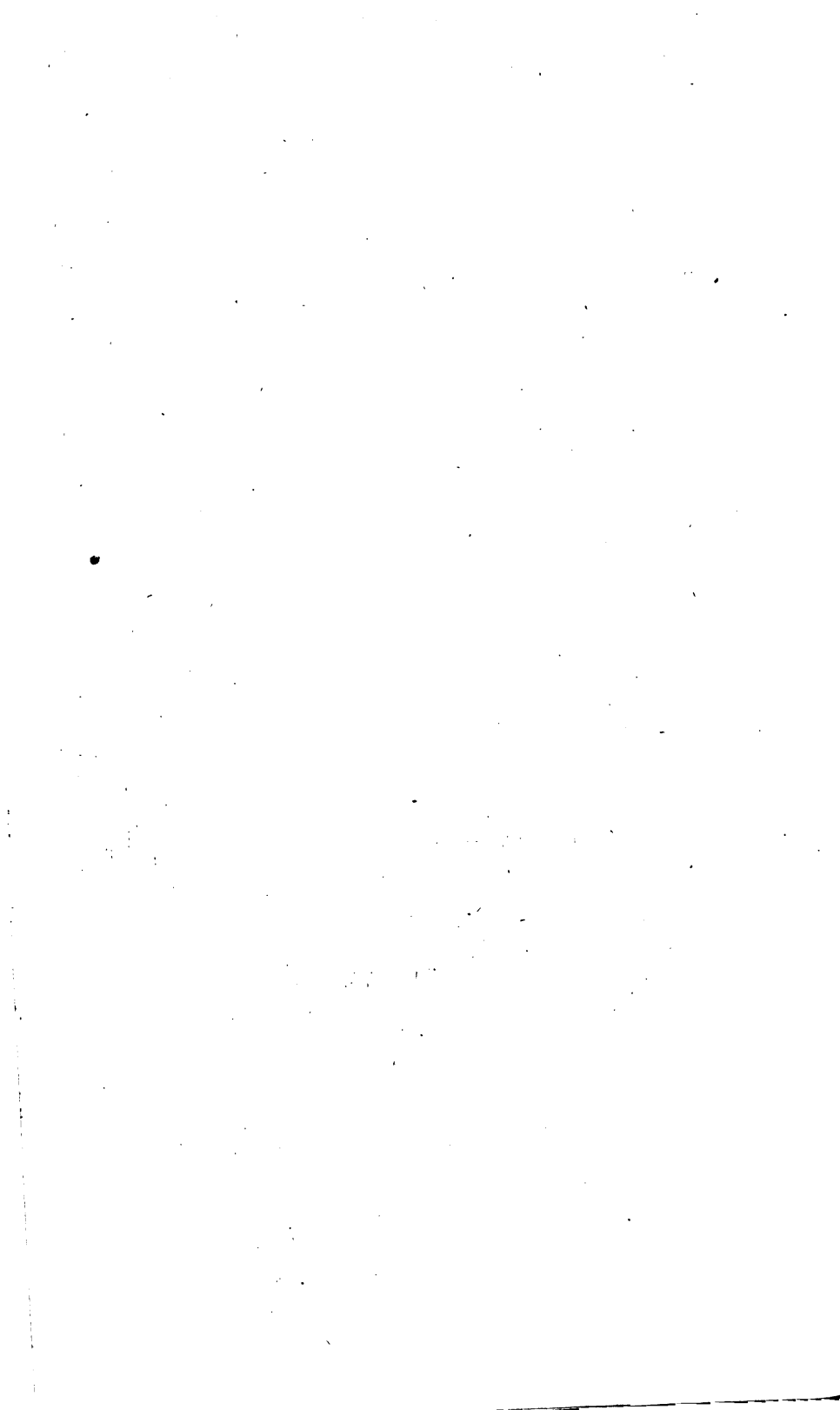


DIAGRAM SHOWING ARRANGEMENT
OF THE "MEYER-SMITH" SYSTEM
OF OIL FUEL BURNING.



When ignition point is obtained the circulating valves are shut and the burners opened and lit by a common torch through a small door on furnace front.

The spray from these burners is of a conical shape and extremely fine and mixing with the air forms a readily ignitable mixture, burning with a good clear flame, once the air is properly adjusted.

No fire bars are used with this system so long as oil only is used.

It is not necessary to have shore steam or use coal for lighting up with. A hand lever is fitted to pump and oil is delivered through a bye-pass into a coil, heated by a paraffin burner, and from thence it is delivered to the burners themselves, or may be circulated back to suction side of pump. When sufficient steam has been raised and the main heater and the pump worked by this means, the starting device (coil and lamp) can be dispensed with.

- 182. About how many tons of steam coal will be burnt per day with good triple expansion engines to drive an ordinary steamer of 40 feet beam 10 knots an hour by steam alone? On what grounds do you say so? What percentage more coal would be required to propel the same steamer one knot faster?**

Ans.—Assuming the lines of the ship to be not finer than about '8, some 20 to 22 tons of coal will be required for a 40-feet beam steamer to go 10 knots per hour, and the reasons for this are as follows:—Taking the average indicated horse power for such a vessel at 1400 and burning, say, 1'5 lbs. of coal per hour per indicated horse power, there will be $\frac{1400 \times 1'5 \times 24}{2240} = 22'5$ tons of coal per day.

To gain one more knot there must be burnt more coal to be found thus:—As the speed cubed varies as the indicated horse power, and as the indicated horsepower varies as the coals burnt, we have the coals used vary as the cube of the speed, therefore, taking the increase upon an original basis of 100 tons, we get—

$$10^3 : 11^3 :: 100^T : - \text{or } 1000 : 1331 :: 100 \\ = \frac{1331 \times 100}{1000} \text{ or } 133'1 \text{ tons now needed,}$$

hence the increase is $133'1 - 100 = 33'1$ per cent. more.

Note by Author.—This shows very clearly how it is that even a slight rise in speed costs us so much more money.

183. About how many tons of steam coal will be burnt per day with a good triple expansion engine, surface condensers, the low pressure cylinder 60" diameter doing average work? On what grounds do you say so?

Ans.—Taking 1400 indicated horse power (as in the last question) and $1\frac{1}{2}$ lbs. of coal per hour per indicated horse power we had 22.5 tons per day.

$$\frac{1400 \times 1.5 \text{ lbs.} \times 24 \text{ hours}}{2240} = 22.5^t$$

Note by Author.—But it would be better for the candidate to take one of his old engines and steamers if the low pressure cylinder is anyway like that given, and work out the consumption from his own data.

The grounds upon which this answer is based are the taking of usual indicated horse power and consumption as is met with in everyday use, but to use the 60 inch low pressure diameter there will be, if the ratio of cylinders is taken at 1 : 2.5 : 6.5, a ratio of diameters of $1 : \sqrt{2.5} : \sqrt{6.5}$ or $1 : 1.58 : 2.54$. $\therefore \frac{60}{2.54} = 23.6$ inches diameter of high pressure and $23.6 \times 1.58 = 37.25$ inches diameter of intermediate pressure so that the nominal horse power may be taken at $\frac{23.6^3 + 37.25^3 + 60^3}{20} = 277$, and if we assume the indicated horse power to be five times the nominal horse power we have $277 \times 5 = 1385$ indicated horse power which is very near to the 1400 we assumed.

184. A pair of inverted cylinder direct acting engines, there is a liner half an inch thick between the ahead eccentric rod and the eccentric strap; in overhauling the engine this piece is lost and forgotten; what difference will its omission make in the working of the engine on the admission, on the cut off, and on the exhaust of the steam? Which will take place earlier and which later, distinguishing between the up stroke and the down stroke?

Ans.—The following will be the effects produced by the omission of a liner $\frac{1}{2}$ inch thick from under the eccentric rod foot. Taking a valve having steam admission over its outer edges and remembering

the valve will now be $\frac{1}{2}$ inch lower than before, the lead on top will be this amount more, whilst the bottom lead will most likely be done away with, at least it will be $\frac{1}{2}$ inch less than before. The cut-off on top will occur later, but that on the bottom earlier, and the top port will open to exhaust late, but the bottom one will open early, and this port will close late, whilst the top port will close to the exhaust early.

The engine will no doubt run in a poor manner, partly due to the great difference in the top and bottom leads, and also to the fact that the area for exhaust at top not being so much now may give rise to an increase in the back pressure and cushioning. The absence of (or great diminution in) the bottom lead will cause her to knock when turning this centre.

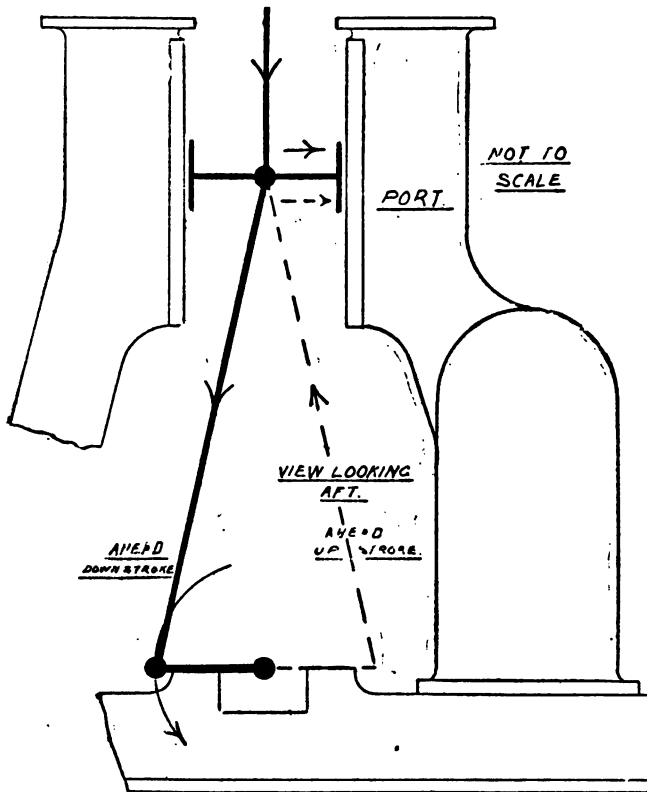


FIG. 72.

185. In a pair of inverted cylinder direct acting engines driving a right hand screw, on which of the crosshead guide bars is the pressure greatest in the up stroke, and on which in the down stroke?

Ans.—The pressure with ordinary marine engines comes entirely upon the port crosshead slipper and guide bar both on the up and the down strokes, though its amount is a trifle more on the down stroke due to the weight of piston and rod acting in addition to the load from the steam pressure. When going astern the pressure comes on the starboard guide, etc.

186. A screw propeller is getting loose, it has a little play on the shaft sideways on the key or feather, how will this show in the engine room?

Ans.—If a propeller is slack sideways on its key it can be both felt and heard in the engine room and tunnel by a knock or bump if the engines be quickly reversed; and after hearing this once or twice it can be readily detected should a slackness arise again after having been previously cured.

186. **ALTERNATIVE SETTING.**—A sharp click or knock is heard when quickly reversing engines. What is its cause?

Ans.—(That already given will do.)

187. How would you prove whether the centre line of the trunnions of an oscillating cylinder be fair with the centre line of the main shaft?

Ans.—To prove whether the centre line of the trunnions be fair (or parallel) with the centre line of crank shaft, take down the crank pin brasses and measure the distance between the side of the T head of piston rod when the piston is on top, and the face of the web, crank also on top centre. Then turn crank to bottom centre, and with the piston also on the bottom measure at exactly the same points and note if the amount is the same; if it is, the trunnions are fair.

188. How can the fairness of a line of screw shafting be tested without lifting the shafts?

Ans.—About the simplest and most accurate method of testing the

fairness of a line of shafting without its being lifted is to slack off all the coupling bolts at the different flanges, and then, either by inspection or trial by means of a "feeler" gauge, ascertain whether the adjacent couplings have opened, and if so whether at the top or bottom and also by how much.

189. Where are steel forgings generally used in marine engines?

Ans.—Owing to the greater strength of mild steel over wrought iron the former has replaced the latter for nearly all the working parts which originally were made of wrought iron, about the only exception being tail end shafts, and these if made of good iron are found not to corrode so quickly nor yet to "fatigue" so soon as do mild steel tail ends. The parts, therefore, made of mild steel are such as piston rods and crossheads, connecting rods, crank, thrust and tunnel shafts, eccentric rods, reversing links, drag rods, pump levers and their links also.

189. ALTERNATIVE SETTING.—What material has practically replaced wrought iron for forgings? Why? Which piece is still made of iron, however, and why?

Ans.—(That already given will do).

190. What is the composition of nickel steel? Where is it sometimes used in engines and boilers?

Ans.—Nickel steel is a good class of steel of about 29 per cent. of carbon and about $3\frac{1}{4}$ per cent. of nickel, and these proportions give an ultimate tensile strength of about 85,000 lbs. per square inch. Plates for boilers are rather lower, about 74,000 lbs., as they are of a milder quality.

It is sometimes used in engines for those parts made of ordinary mild steel, but its expense is against its larger use, and about the commonest place to find it is in tail end shafts, as it resists corrosion better.

For boilers it is not much used, but when specified it is generally for shell plates.

191. How is forced draught generated on board ship and supplied to boiler furnaces? Is the air heated before delivery? If so, how?

Ans.—Forced draught consists of a fan driven either by a small

steam engine or by an electric motor. This fan generates a current of air that is at the stokehold temperature and sends it to a heating chamber situated in the uptake, where by passing on the outside of short vertical tubes, through which the hot waste gases of combustion pass, the air is raised in temperature up to as high as 250° to 300° F. The fan still urging the air onwards, it passes by special trunks down to the furnace fronts, which are also specially made so as to regulate the admission of the heated air both on top of the fire and some into the ash pit. (See plate V.)

192. What is "induced" draught? Compare the merits of "forced" and of "induced" draughts.

Ans.—Induced draught consists in having a fan acting as a suction in the upper part of the uptake casing and by its expelling the heated products of combustion up the funnel at an increased velocity, there

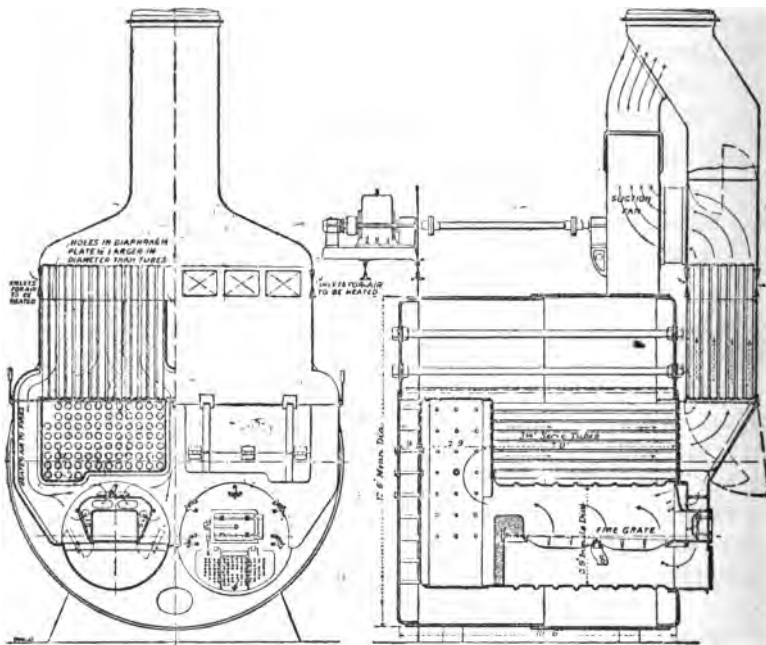
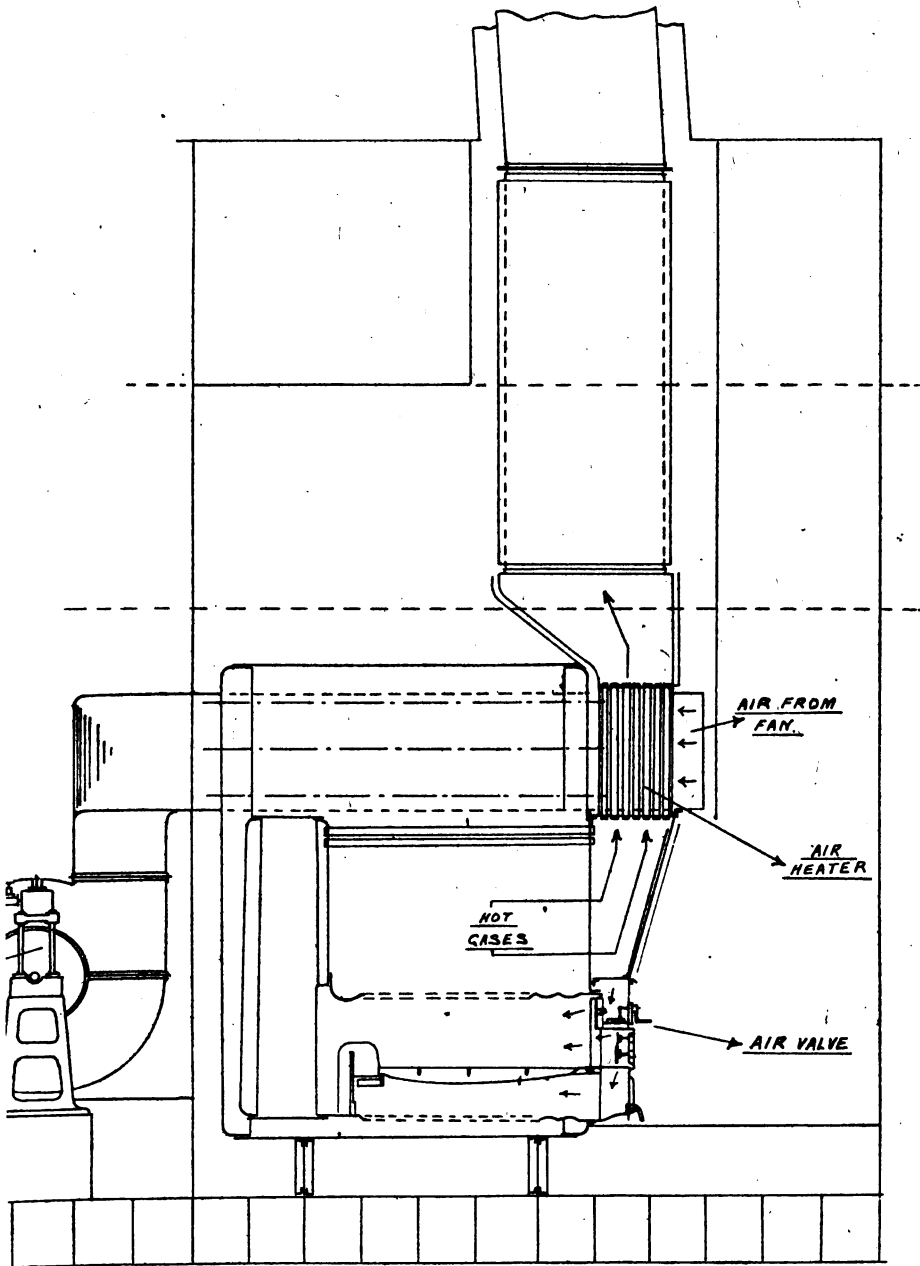


FIG. 73.

is produced a slight vacuum, and to destroy this air from the stokehold rushes into a heating chamber consisting of an enclosed space having

PLATE V.



To face page 142.

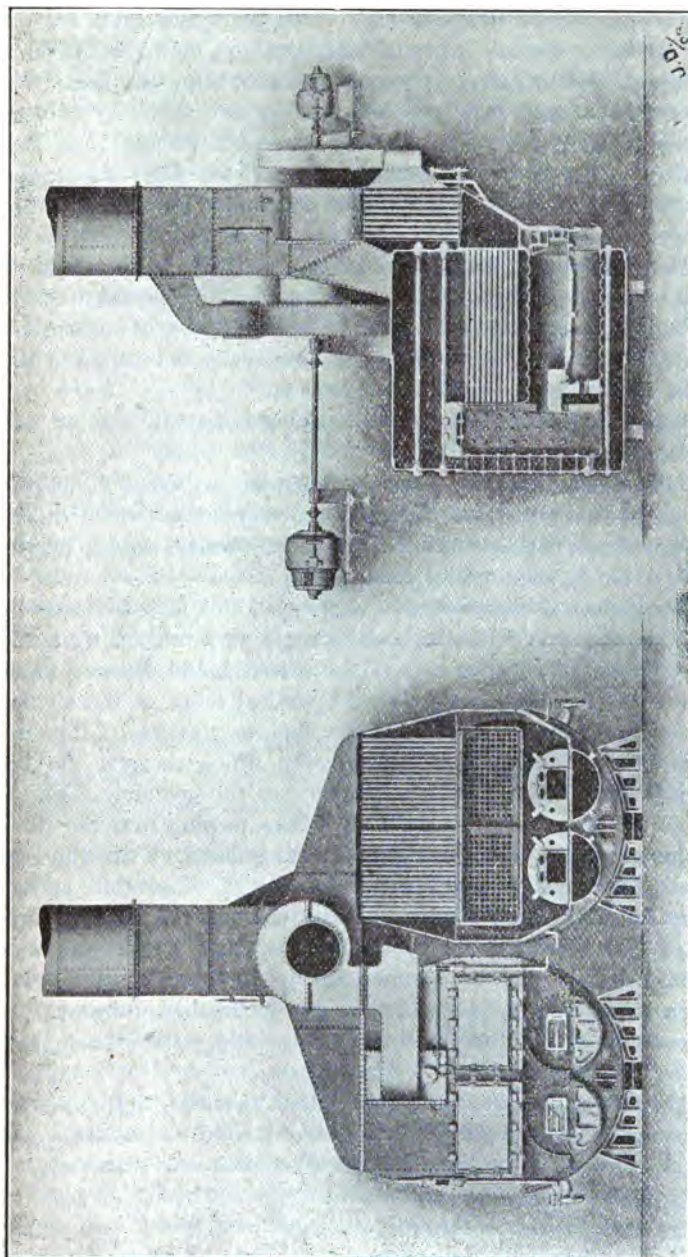


FIG. 74.

a series of vertical tubes through which the waste gases are drawn. The air being outside is heated and then goes down to the furnaces, being regulated by valves to pass above and below the fires. It thus mixes with the gases from the coal and passes thence up through the ordinary smoke tubes and next the heating tubes and then through the fan and away to the funnel. One of the chief advantages of induced draught is that the furnace doors may be opened whilst the draught is on, whereas with forced draught this must be shut off *before* opening the doors. Also the suction system is not so fierce in its effects upon back ends and the like, but against this must be set the fact that the fan has to actually deal with the heated products of combustion.

Note by Author.—The following pars. need not be given as part of the answer unless the candidate likes to :—

Figure 74 shows the "Atlas" balanced draught and air heating economisers.

The system consists of a combination of induced and forced draught in conjunction with air heating economisers which utilize the waste heat of the gases as they leave the boilers to regenerate the whole of the air required for combustion.

To produce this combination of draught, two fans are used in the following manner :—The induced draught is produced by a suction fan which is placed at the base of the chimney, and drawing the waste products of combustion through the vertical tubes of the air heating economisers, delivers them into the flue or chimney. The forced draught is produced by a pressure fan which delivers the correct quantity of air required for combustion into the economiser where it is heated up to from 300° to 350° F. before passing into the furnaces. In this way the air supply is accurately regulated to suit the requirements of combustion, and it is raised to a high temperature entirely by means of heat which would otherwise pass up the chimney and be wasted. The term "balanced draught" is used because the fans are so proportioned that the vacuum set up by the suction fan is just sufficient to overcome the resistance due to the flues, tubes, etc., when the pressure fan is setting up the requisite under-grate pressure to burn the required amount of coal.

The draught at the furnace door is thus balanced, so that there is no outrush of flame or inrush of cold air when the furnace doors are opened, as is the case when forced or induced draught is used separately.

The fans may be located where most convenient, and driven by independent motors or engines, so that their speed can be readily varied to suit the conditions of working.

Incidental advantages obtained are that the driving power required is appreciably less than with a single fan, owing to the smaller frictional resistance of the air; the pressure fan is dealing with cold air only, and the suction fan with gases that are already considerably cooled by the air heating economiser. Also as the water gauge maintained by each fan is only about one-half that required with a single fan for the same duty, the losses through any leakage in the boiler settings are correspondingly diminished.

The effect of the system is to cause complete combustion at once, no smoke whatever being formed. At the same time a high rate of evaporation is obtained and great economy in fuel. The heating of the air enables the air supply to be greatly reduced, which is in itself the principal factor in the economy obtained. To explain this point clearly, when cold air is used the quantity of air required is generally about 24 lbs. per lb. of coal, whereas with the "Atlas" system from 17 to 18 lbs. of heated air proves sufficient. This reduced air supply naturally has the effect of greatly raising the temperature of combustion, as besides the gain of temperature in the heated air, it avoids the loss of having to heat up the usual excess of inert air.

The result obtained is a great increase in the steaming capacity of the boiler, combined with high efficiency, and consequently a very great saving in fuel consumption.

193. How is the intensity of forced or induced draught measured? What is the usual pressure employed in the Mercantile Marine?

Ans.—By ascertaining the difference in height of two columns of water in a U tube, thus: A glass tube of about $\frac{3}{8}$ inch to $\frac{1}{2}$ inch diameter of bore is worked U shape and mounted upon a board carrying a scale of ordinary inches. Water either plain or by preference coloured is poured into this tube until the levels stand at about $1\frac{1}{2}$ inches to 2 inches above the bottom of the U. To the top of one leg is attached a pipe leading from the spot where the draught intensity has to be measured, and the top of the other leg is left open to the atmosphere. Now as the fan generates the air current, so its pressure rises and thus the water in one leg goes down, whilst that in the other leg rises by exactly the same amount. Thus if the water shows a difference in levels of 2 inches we say there is an air pressure of 2 inches or as each inch equals 5.2 lbs. per square foot, 2 inches will mean 10.4 lbs. per square foot air pressure.

Usual air pressures for the mercantile marine are at the fan, from 2 inches to 3 inches; above the fire, about $\frac{3}{16}$ inches to $\frac{1}{2}$ inch, and below the bars about $\frac{1}{4}$ inch or a little more.

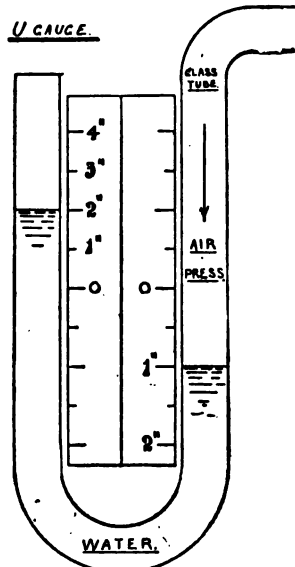


FIG. 75.

Note by Author.—In the fig. 75 it will be seen that we have shown the right hand scale actual inches, but upon the left hand scale each *actual half inch* is taken as one inch, and therefore a reading upon this scale gives by its figures the real inches of pressure due to the difference of levels in the two legs. Gauges are usually marked on *both* scales as is here shown on the left.

193. ALTERNATIVE SETTING.—In estimating draught pressures by a U gauge why is the unit of area chosen as a square foot?

Ans.—One cubic foot of fresh water = 62·5 lbs., and is on a base of 1 square foot. Each inch height is therefore $\frac{62\cdot5}{12} = 5\cdot2$ lbs., 1 square foot = 144 square inches, hence to give an air pressure of, say, $\frac{1}{2}$ " water in terms of a square inch would be $\frac{5\cdot2}{2} \div 144 = \cdot018$ lb., a figure which the mind cannot readily grasp, and so it is usual to express the pressure in terms of the larger unit.

194. An explosive gas is liberated from bunker coal. Usually in well-ventilated bunkers this gas escapes into the atmosphere without doing harm. In ill-ventilated bunkers the gas, after mixing with a certain proportion of common air, has been known to explode when a naked light has been brought into contact with it. What is the composition of the gas? Where is it found in bunkers, 'tween decks, pockets and coal shoots? How may it be got rid of as soon as it evolves from the coal? How many cubic feet of air to one of the gas forms a violent explosive mixture?

Ans.—When coal has been stored in a confined place for a short time it gives off a light gas known as “marsh gas,” which is a light carburetted hydrogen represented by the letters $C H_4$, which means that in a given amount of the gas 4 parts are hydrogen and 1 is carbon. Marsh gas is what is known to the coal miner as “fire damp.” Before it becomes explosive it must be mixed with air in any proportion between about 6 cubic feet of air to 1 cubic foot of the gas, up to about 12 of air to 1 of gas; a proportion of about 9 air to 1 gas yields a violently explosive mixture when a naked flame is brought into contact with the “mixture.” Whilst efficient ventilation will remove this dangerous gas, yet as such can rarely be obtained, volumes will accumulate at all the high places in bunkers, 'tween decks and shoots, and about all that can be done to minimise danger is to ship the coal dry and in as large pieces as possible, then to keep hatches off as long as the weather permits, and to keep all ventilators full open, and as very often the ventilators are made as part of the masts or derricks, the actual openings come well out of reach of seas shipped by the vessel.

195. A lighted lamp or candle has sometimes been lowered into an apparently empty paraffin tank and produced an explosion resulting in injury to the person holding the light. What did the tank probably contain, and what produced the explosion?

Ans.—An apparently empty paraffin tank often contains a large amount of a dangerous hydro-carbon gas, something like marsh gas, only being a heavier compound, viz., $C_2 H_6$. This is due to the fact that all paraffins or petroleums are combinations of the gases carbon and hydrogen in various proportions and both mechanically mixed

together, and as small quantities of the oil remain about the tanks in thin layers, they readily pass off this gas which is not only explosive when mixed with air, but is fatal to human life if one becomes immersed in it for more than a few seconds. It is a heavyish gas and tends to sink to the tank bottom, but if through working one's legs about in it, it becomes disturbed, mixed with air, and a naked flame be present, it explodes violently.

195. ALTERNATIVE SETTING.—If lamps or candles lowered into apparently empty paraffin tanks have caused explosions, what kind of illuminant would you prefer for safety? What is the nature of the gas in the tank?

Ans.—Either a Davy safety lamp or an electric one with a gas-tight switch. The former has the flame surrounded by a wire gauze case, and if a lambent blue flame is seen to burn inside this it tells us the dangerous gas is present and passing through the meshes of the gauze. For the time this absorbs the heat and prevents the flame passing back to the bulk of the gas, but we should remove from the danger spot, because if the gauze gets red hot it will fire the whole mixture.

Gas-tight switches are necessary with electric hand lamps, as otherwise the spark caused on switching off will fire the mixture. (Then continue the answer as already given.)

196. In vessels carrying coal cargoes it has been observed that, generally speaking, the gas which escapes from the body of the coal is found more abundantly at the forward end of the hold than at the after end. Why should this be so?

Ans.—As the gas is lighter than air it naturally tends to rise and occupy the highest spots, and as a vessel usually trims more by the stern that elevates the fore ends of holds, further, the action from ventilators will at times tend to drive the gas also to the highest parts.

197. In recently opened ballast tanks, double bottoms, and boilers a light lowered into either has sometimes been extinguished. What would, in all probability, cause this?

Ans.—The extinguishing of a light when lowered into a hitherto

closed boiler or tank is due to the presence therein of an undue amount of carbonic acid gas (CO_2) caused either from a decomposition of the paints or enamels used in coating tanks or else from oils or sediments in the boiler. The oxygen of the air which was in both tank and boiler at first combines with the carbon of the above substances and so produces CO_2 , and it would appear as though the other constituent of air, nitrogen, remains as a kind of free gas, and neither this nor CO_2 is of any use to support combustion, hence the light goes out or at least burns feebly.

198. In double bottom steamers where does the bilge water lie, and where are the roses of the bilge pipes fitted?

Ans.—In a vessel that is tanked right through, spaces called “bilges” are provided by the skin of the ship and the tank side and it is in these “bilges” that the water lies and into these the ends of the

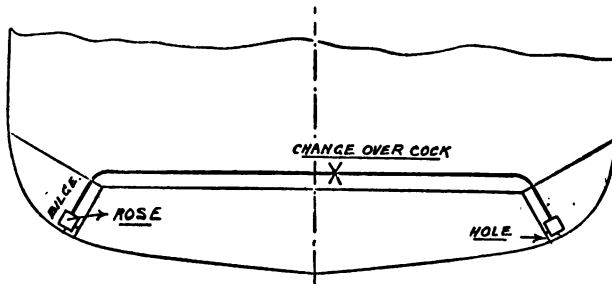


FIG. 76.

bilge pump suctions fitted with rose boxes lie, one for the port bilge and one for the starboard. A small hole is cut at the bottom of the bracket plate which connects the tank side, or margin plate, to the skin of the ship, and by this hole the bilge water is allowed to pass right through between the different bulkheads, but not through these.

199. What is the advantage of a large rose over a small one?

Ans.—If a rose box be made small it naturally becomes choked quickly and therefore often requires cleaning, hence roses should be as large as practicable:

200. Why, especially in vessels carrying cargoes liable to shift, should engine bilge suctions be fitted to both wings of the bilge?

Ans.—Through the cargo shifting, the ship will take a permanent list and thus all the bilge water will run to the lower bilge and as this may be either the port or starboard one, it is necessary to have a bilge suction leading from both, otherwise the water sometimes could not be removed.

201. In a heavily listed vessel why is it difficult to keep steam?

Ans.—As a ship lists so it brings the wing combustion chambers nearer to the water level of the boilers and it may be actually out of the water. To overcome this and prevent burning of the chamber tops, etc.,

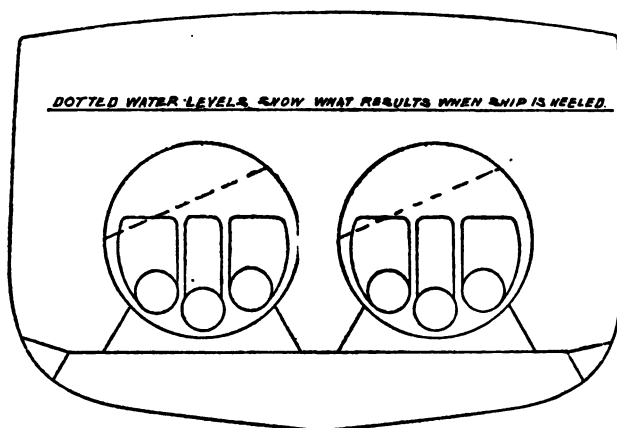


FIG. 77.

we must pump more water into the boilers and this reduces their steam space and is one of the causes for difficulty in maintaining a good pressure. Other causes are that priming will most likely be found, owing to the higher level and decreased steam space and so as priming bodily carries away from the boilers so much of the water which is heated but not turned into steam, more feed must be sent in in a given time. Also owing to the slope of the stokehold plates, firing will be a difficult matter to carry out and the pressure will fall from this. As the combustion chamber sides now all slope, some of them act as baffles to

the steam formed upon them, owing to their being more on top of the steam as it were.

- 201. ALTERNATIVE SETTING.**—Steam is often found to fall back when a vessel has a bad list. Why should this be so?

Ans.—(That already given will do).

- 202.** If the engine bilge pumps get choked and water accumulates in the stokehold bilges what effect does the water have upon the bilge boards and stokehold plates when the ship is rolling violently.

Ans.—Should the water be allowed to rise in the bilges, it will force up the boards and stokehold plates as the ship rolls, because the accumulated water swishes about and then when the boards, etc., are displaced, any rubbish like, ashes, coal, etc., gets directly to the bilges and soon chokes the suction to the pump.

- 203.** In a triple expansion engine what spare gear do you consider necessary in the case of a foreign going ship? Also, what stores would you provide for a voyage to New Zealand?

Ans.—The following may appear to be rather a lot, but they are what should be obtained and carried for the run mentioned in the question.

Spare Gear for Main Engines.

- 1 tail end shaft and 1 propeller to fit its taper.
- 8 coupling bolts and nuts, which have been seen to fit the holes in the couplings
- 1 bottom end brass with its two bolts and nuts.
- 1 top end brass with its two bolts and nuts.
- 1 eccentric strap with its two bolts and nuts.
- 1 valve spindle with nut to fit.
- 2 main bearing bolts and nuts fitted.
- 12 junk ring bolts.
- 12 cylinder cover studs and their nuts.
- 1 complete set of piston rings, either patent or Ramsbottom; just as are at present fitted for the high pressure, intermediate pressure and low pressure cylinders.
- Studs and nuts for the different stuffing box glands (unless the engineers make such as are required).
- 1 air pump rod and 1 feed pump plunger.

Spare Gear for Main Engines—Continued.

- 1 each feed pump suction and delivery valves.
- 1 complete set of metallic valves and guard for air pump.
- 1 suction and delivery valve for bilge pump.
- 1 spare crank suitable for either high pressure, intermediate pressure or low pressure.
- 1 Thompson's shaft coupling.

Auxiliary Engines, Spare Gear.**WEIR'S INDEPENDENT FEED PUMPS.**

- 1 valve spindle.
- 1 bucket and rod complete.
- 12 suction and delivery valves.
- 6 springs for valves.

FAN ENGINES.

- 2 sets of piston rings.
- 1 connecting rod with brasses, etc., complete.
- 1 piston and piston rod complete with brasses, etc.

BALLAST PUMP.

- 1 plunger rod or bucket.
- 1 set piston springs.
- 1 set suction and delivery valves.

CIRCULATING PUMP, WHEN DRIVEN BY SEPARATE ENGINE.

- 1 set piston rings.
- 1 eccentric rod, strap and valve spindle, complete with nuts and bolts.
- 1 connecting and 1 piston rod complete with brasses, etc.

Winches and Windlass.

- 12 piston rings, winches.
- 6 piston rings, windlass.
- 2 sets of main bearings for windlass.
- 2 sets of bottom end brasses for windlass.
- 4 valve spindles and one gland for winches.
- 1 piston rod and gland for winches.
- 1 piston.
- 2 sets main bearing brasses for winches.
- 2 sets bottom end brasses for winches.
- 2 sets top end brasses for winches.
- 1 spur wheel (in halves).

Stores.

320 galls. engine oil.	1 cwt. red lead.
150 „ colza oil.	1½ „ red lead oxide.
40 „ cylinder oil.	2 „ brown oxide.
200 „ paraffin.	2 „ stone colour.
4 cwt. waste.	1 „ black.
1 „ white lead.	7 lbs. blue.
2 „ white zinc.	8 galls. turpentine.

Stores—Continued.

6 cwts. linseed oil.	6 gauge glasses or donkey boiler.
8 „ boiled oil.	24 zinc plates.
1 „ terebene.	1 check valve and spindle each or main and donkey boilers.
2 kegs soft soap.	2 safety valve springs for main boiler and 1 for donkey boiler.
56 lbs. bar soap.	1 safety valve and seat for main boiler.
6 cwts. soda.	24 tubes for main boiler.
2 galls. carbolic acid.	12 tube stoppers.
18 balls colza wick.	80 fire bars for main boiler.
6 rolls $\frac{3}{4}$ " lamp wick.	30 fire bars for donkey boiler.
5 doz. sheets emery cloth (assorted grades).	2 bearers for fire bars.
$\frac{1}{2}$ lb. emery powder (fine).	6 ft. each muntz metal rod, sizes $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ ", $\frac{5}{8}$ ", $\frac{3}{4}$ ", $\frac{7}{8}$ ", and 1".
1 cwt. lime.	6 ft. each iron rod, sizes $\frac{1}{2}$ ", $\frac{3}{4}$ ", $\frac{7}{8}$ ", and 1".
24' duriflex packing $1\frac{1}{8}$ ".	6' x 3' muntz metal sheet $\frac{1}{32}$ ".
36' „ „ 1".	3' x 3' „ „ $\frac{1}{16}$ ".
24' „ „ $\frac{7}{8}$ ".	3' x 3' „ „ $\frac{3}{8}$ ".
24' „ „ $\frac{3}{4}$ ".	2' x 2' „ „ $\frac{1}{4}$ ".
48' soft „ $\frac{3}{4}$ ".	2 lbs. lead wire $\frac{1}{16}$ ".
2 balls asbestos.	1 lb. copper wire $\frac{1}{16}$ ".
12' each of Tuck's packing sizes $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ ", $\frac{5}{8}$ ".	6 chipping hammers.
48' asbestos tape $\frac{3}{4}$ ".	4 lbs. black lead.
6' x 6' red wire insertion $\frac{1}{16}$ ".	56 lbs. tallow.
6' x 6' wire asbestos cloth $\frac{1}{16}$ ".	6 tar brushes.
20 boiler door joints $15'' \times 12'' \times 1''$.	6 paint brushes.
6 „ „ $16'' \times 12'' \times 1''$.	6 brooms.
200 fire bricks.	6 mats.
3 cwts. fire clay.	6 washing buckets.
1 cwt. cement.	8 ash buckets.
6 hand lamps (spare).	24' wire for ash hoist.
3 doz. lamp glasses.	2 each $\frac{1}{2}$ " and $\frac{3}{4}$ " packing drawers.
6 stoking shovels.	60' of $1\frac{3}{4}$ " rope for air and ballast pump plungers.
3 trimming shovels.	
2 doz. each bolts and nuts, sizes $\frac{1}{2}$ ", $\frac{3}{4}$ ", and $\frac{1}{2}$ ".	
3 doz. each, washers, sizes $\frac{1}{2}$ ", $\frac{3}{4}$ ", and $\frac{1}{2}$ ".	
24 gauge glasses for main boiler.	

And in addition to the above the ordinary stock of tools must be kept up.

204. What means are sometimes provided for temporarily coupling together the broken parts of, say, a tunnel shaft? Describe the fitting.

Ans.—The means usually adopted is to fit what is called a Thompson patent coupling round the shaft at the break. This consists of a strong clamp made of cast steel, about $2\frac{1}{2}$ inches thick and of lengths varying from 3 to 4 feet. They may be in either two or three parts circumferentially in order that they may go over the shaft. Strong bolts then

pass through the flanges of each part of the coupling and draw the whole lot tight down on to the shaft, having first seen that the ends of the break are close together. With one form of shaft coupling further set

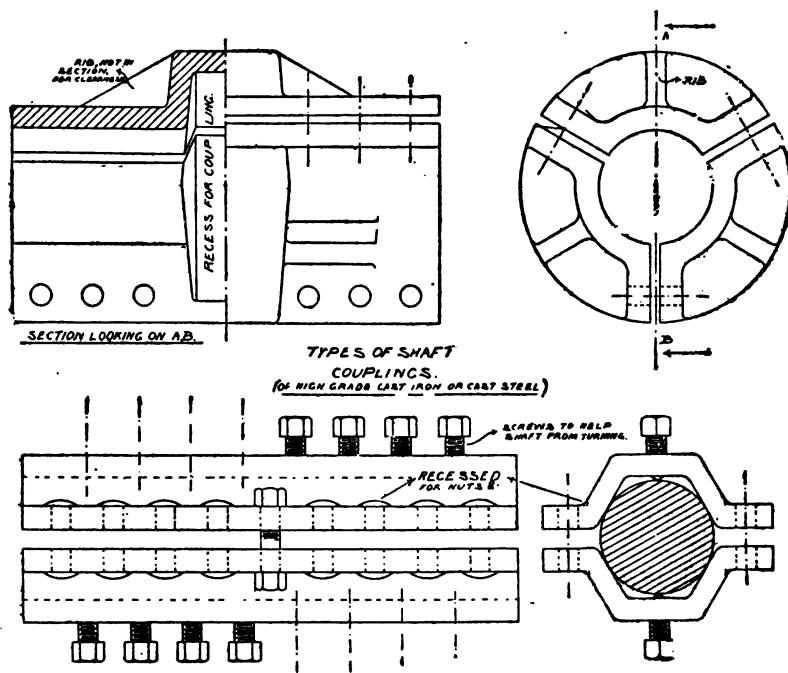


FIG. 78.

bolts are provided in the two parts of the coupling itself and these are tightened down on to the shaft after the halves have been drawn together as explained above, and thus further help to secure the broken parts.

205. Does the pressure on the thrust collars vary with the horse power, or with the speed of the ship, or how?

Ans.—The thrust pressure varies inversely as the speed, and directly as the indicated horse power. Thus suppose the ship's speed to be 10 knots with a certain indicated horse power and through some cause it drops to 9 knots with the same indicated horse power, then the thrust pressure will *increase* in the ratio of 10:9 or will be 1.11 times as great. If, however, the indicated horse power drops, then the thrust pressure drops proportionally to this.

- 205. ALTERNATIVE SETTING.**—If the speed of the ship varies how does that affect the thrust pressure?

Ans.—(That already given will do).

- 206.** If the holding-down bolts of a thrust bearing should become slack, what effect would it have upon the working of the engines?

Ans.—Should a thrust bearing become slack and so allow itself to be forced forward by the thrust from the screw, the whole shafting, including crank shaft moves also and thus the forward webs come against the main bearings, and perhaps crank pin becomes fractured through bending, besides causing the bearings to run very hot. This throwing out of line of the whole shafting brings the connecting rods away from the straight line and so bottom and top end brasses run hot as well. The valve motion also will give trouble and in short the whole engine works badly by thus being thrown out of line.

- 208. ALTERNATIVE SETTING.**—You find the bottom and top ends running hot and the lubrication is as usual, what is wrong? Or the shaft cracks at the pin? State possible cause for this.

Ans.—(That already given will do).

- 207.** In an engine with three cranks, which of the three is subject to the greatest torsional stress (1) in going ahead, (2) in going astern.

Ans.—Seeing that the low pressure crank has to transmit the effort of both intermediate pressure and high pressure, as well as its own, the shaft at No. 6 bearing is more heavily stressed than any of the others, and this is the case whether going ahead or astern.

- 208.** Is it usual to make the crank shaft of a triple or quadruple expansion engine in one piece? And is the diameter of the shaft uniform from end to end? Give your reasons for the practice which obtains?

Ans.—The crank shaft of a triple or quadruple engine is always made of either three or four separate cranks bolted together and very often each of these cranks is made of five pieces, the two shaft portions.

with the couplings, the two webs, and the crank pin, the whole being shrunk together to form the crank. The diameters of the pins and shaft portions are all the same right through, in order that each crank may be interchangeable with either of the others, in the event of having to replace, say, a fractured low pressure one by putting the high pressure crank into its place. Also it is cheaper to manufacture an engine where the shaft diameters are the same all through.

The reason for subdividing the crank shaft is to enable sounder forgings to be produced in the first place, because the smaller the part the more reliable will be its manufacture, and secondly for the sake of substitution as explained before. About the largest crank forging is where both webs, pin, and two shaft parts are made solid and then care must be taken to obtain the grain of the iron running as nearly as possible in the lines of the different parts.

208. ALTERNATIVE SETTING.—What governs the diameter of a crank shaft? Could it be made of varying diameters? Why is this not done so as to save weight?

Ans.—The shaft could be made of increasing diameters, starting with the piece in No. 1 bearing (high pressure forward end) the smallest, No. 2 bearing a little larger, No. 3 larger again, and so on to No. 6, which would be the largest of all. This would be brought about by reason of No. 1 bearing having no torsion (except the resistance of the valve gear to overcome), and only half the bending moment due to load and leverage from high pressure engine. No. 2 bearing has the half bending moment plus torsion of high pressure. No. 3 has torsion of high pressure plus half bending moment of intermediate pressure (and which may be more than was the high pressure). No. 4 has torsion of intermediate pressure and high pressure, plus half bending moment of intermediate pressure. No. 5 has the two torsion efforts, plus half bending moment of low pressure, and No. 6 has the other half, plus *all* the three torsion efforts, and thus would need the larger diameter shaft. Shafts are not made of varying diameters, as if so they would *not be* interchangeable, and seats for bearings would each have to be planed out on its own. These facts far outweigh the saving of weight.

209. In a "built" crank shaft how are the webs rigidly secured to the pins and to the body of shaft?

Ans.—A built crank being composed of five parts it is necessary to rigidly attach the two webs to both crank pin and shaft parts. This is

done by boring each hole in each web a *trifle* less (about $\frac{1}{8}$ inch approximately), than the diameter of pin or shaft. By means of gas heaters the web is then heated and the holes expand this small amount

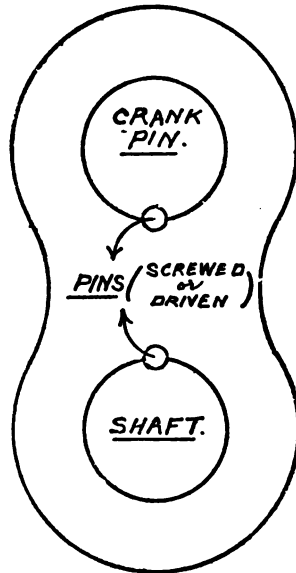


FIG. 79.

and being then placed over pin and shaft are allowed to cool and so contract tightly upon each. Then to secure them finally in place should the contraction not be sufficient to ensure the webs remaining fast and tight after usage, holes are drilled, half in web and half in pin or shaft respectively, of a fair diameter, and pins driven or screwed hard home into these holes. Care must be taken to have these pins at least about $\frac{3}{4}$ of the thickness of web and of such a diameter as will reduce the shearing stress on their longitudinal section to a safe amount, of say, about 5000 lbs. per square inch, as *should* the webs become slack it is only these pins hold the lot in place.

210. There are various descriptions of donkey engines in use on board ship for pumping purposes. Some pumps are fitted with escape valves, some are not. Why should this be?

Ans.—Any pumps which have fly wheels to them, or are driven direct from the main engines, should have escape or relief valves fitted

in case a nip occurs anywhere in their discharge. Should this happen the escape valve will open and relieve the pump chamber or pipe. All common donkey and plunger pumps require such valves, but pumps of the Weir and Worthington types do not, even though such are sometimes met with, because with these the steam and water pistons are so nearly equal, that a moderate rise on the discharge side quickly balances the effort of the steam and the pump stops, whilst the main engine driven pumps and also those having heavy moving parts would continue to move after the nip occurred and so raise the pressure in pipe or chamber to its bursting point.

- 210. ALTERNATIVE SETTING.**—Suppose a donkey pump were not fitted with an escape valve, what might happen? Do all kinds of pumps have these?

Ans.—(That already given will do).

- 211. Explain the function of an air vessel fitted to a feed pump. Make rough hand sketches of (1) a satisfactory vessel, and (2) an unsatisfactory vessel, where, say, the air spring has been destroyed by carelessness, or has never been properly provided.**

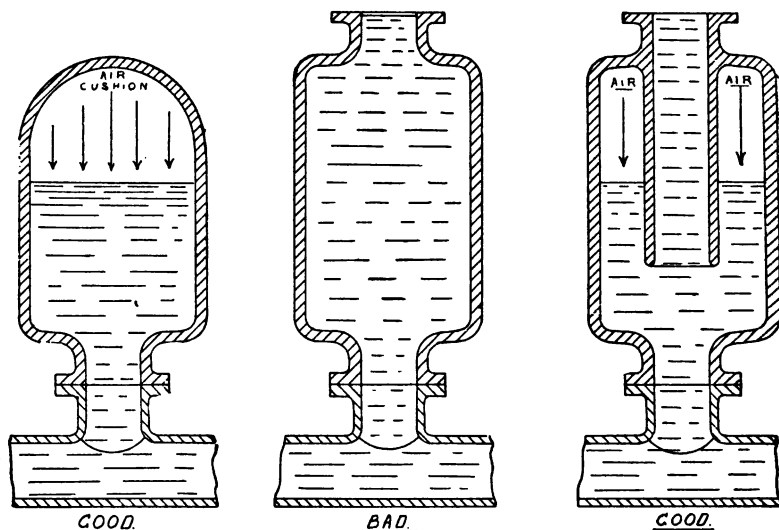


FIG. 80.

Ans.—An air vessel consists of a cast iron vertical chamber placed upon the discharge pipe from a forcing or plunger pump, and its object is to allow the air to collect in its upper part and be compressed by the water driven along the pipe, some of which rises in the “air vessel” on each discharge stroke of pump. The air being thus compressed re-acts on the water, and during the suction stroke of the pump, it forces some of this out of the air vessel and along the pipe to the discharge and by this means the flow is made much more nearly continuous and at the same time the shocks given to the water by each down stroke of the plunger are absorbed by compressing the air cushion. A satisfactory type is shown in fig. 8o at left, where the air accumulates at the top and can re-act as explained before, and fig. 8o (centre) shows an unsatisfactory type in which no air cushion or air spring exists at all; fig. 8o (right hand) shows an alternative form of satisfactory vessel, as the air can accumulate round the internal pipe.

211. ALTERNATIVE SETTING.—What is fitted to the discharge pipe of a donkey pump in order to make the flow more continuous? Are there bad forms of this fitting as well as good ones? How can you distinguish between them?

Ans.—(That already given will do).

212. Should cocks or escape valves be fitted to air vessels? Why or why not?

Ans.—No cock, escape valve or opening of any sort should be allowed upon an air vessel, except it be one with an internal pipe. The reasons for such exclusions are that a valve, etc., might leak and so reduce the air cushion and further that each time the valve acted as the relief, away would go the whole of the air cushion and for some time after this the air vessel would be useless. Escape valves should always be fitted between the feed suction and delivery valves, on the pump chamber itself, as this is the first place to feel an excess of pressure and there is no air spring to lose.

212. ALTERNATIVE SETTING.—With a plunger pump will the water yield to the descending ram if the delivery and escape valves are fast? If not, what would result?

Ans.—The water is for all practical purposes incompressible, and

so if the valves mentioned are stuck fast it will not yield, and therefore the pressure in ram chamber rises dangerously high, bursting it.

Note.—Water can be compressed about '33% for a pressure of 1000 lbs. per square inch.

213. Where, by preference, should the escape valve of a pump be placed? Why?

Ans.—Note by Author to Candidates.—This question has practically been answered in the last part of what is given to Q. 212, but add that the cause of such excess of pressure might be the check valve sticking fast, or the delivery valve refusing to lift.

214. Scum cocks are sometimes fitted to boiler shells at a height convenient for engineers to manipulate when standing in the stokehold: the scum pipes in such cases are led upward, inside the boiler, to a little above the combustion chamber tops. What danger may arise from this arrangement?

Ans.—The arrangement mentioned is about the worst that could be fitted, as, firstly, the pipe sloping upwards to the scum pan tends to become choked with the solid matters in the water. Secondly, the pipe may corrode through at its connection to the spigot of the cock and drop off, so that instead of removing dirty water when ostensibly "scumming" the boiler, good clean water would be blown out and so wasted, leaving the dirty lot still at the water level. One advantage of placing a scum cock at the working level of the boiler is that if the pipe breaks off then steam comes practically at once when the scum cock is opened.

215. Cocks for testing the water level of boilers are sometimes fitted within reach of the engineer who is standing in the stokehold. These may have internal pipes leading upward and terminating at various levels. Under what circumstances may these become misleading?

Ans.—Being internal pipes they are liable to choke and also bending down and so recording false water levels, and whilst this action may be prevented by having the internal pipes supported by efficient hangers from the boiler stays, still they may corrode through and break off, again

leading to false indications when the test cocks are used. If the one leading up to the steam space dropped or sagged it would sooner or later enable water to be blown through the steam cock.

- 215. ALTERNATIVE SETTING.**—Is it advisable to fit internal pipes in a boiler to such as scum cocks and water gauge cocks? What is their great danger?

Ans.—(That already given will do).

- 216.** Why should the pipe which leads from the bottom of the water gauge column to the bottom of the boiler front, or back, be covered with non-conducting material? Why also should it never have lengthy horizontal bends?

Ans.—In order to obtain accurate indications in the gauge glass of the height of water in the boiler, it is necessary that the temperature of the water pipe and its contents be kept as near those of the boiler as ever possible, hence the pipe should be well lagged, and by this means we prevent the undue cooling and contraction of the stagnant column of water. It must be noted that when this water is cooled considerably below that of the boiler that a *less* height will balance the boiler height of water, as cold water is denser—*i.e.*, weighs more to a given volume, or what is the same thing, has a less volume for the same weight. Lengthy horizontal parts only increase the liability to fracture by increasing the weight and leverage from the boiler, and if the whole is not blown through often the dirt, etc., tends to collect in such horizontal parts.

- 217.** In your own experience how frequently is this pipe removed and cleared?

Ans.—Note by Author.—The candidate must answer this question from his actual experience of such cleaning

- 218.** Why, even with the best of water gauges, is it advisable occasionally to use the drain cock?

Ans.—In order to prove that the glass water gauge is reliable and working properly, the whole affair should be blown through periodically at not too long intervals, thus the drain cock comes into use.

The *trick* for such blowing through is to see that the cocks are *sure* and are *worked* up and such blowing through should at once be *reversed* so that the water *stationary* or *practically* so in the *gauge* as when everything is *perfectly* clear the level is always *varying* up and down. Even though all cocks, etc., may be clear, yet to blow through the gauge and its pipes does good, in so far as it removes the *column* of *vapour* and *colder* water in the bottom of water pipe and on again putting the gauge into use, this becomes filled with hot water at *higher* temperature and we are thus enabled to see really where the *level* is. Also we *blow* out any fresh water that may have trickled into the *gas* by *condensation* of steam in the upper pipe.

219. Steam loops have sometimes been inadvertently made in the length of piping leading from the top of the water gauge column to the top of the boiler. Roughly sketch such a loop and explain the danger arising from its existence.

Ans.—Should a bend forming a trap be worked in the upper or steam pipe of a water gauge mounting, serious errors in the indications of the gauge will result. The steam as it condenses runs to the bottom of such trap and forms a small mass of water, constantly getting larger,

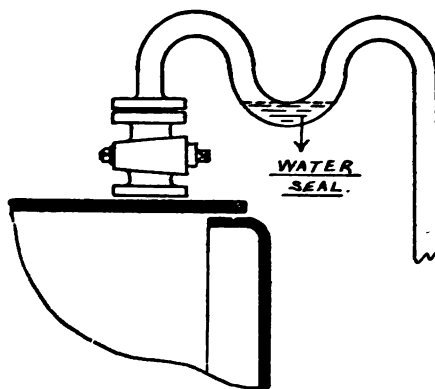


FIG. 81.

until at last it fills the pipe. When this happens the steam that is between the water in the trap and that in the glass becomes condensed, or at least some of it does, and a lowering in the pressure is thereby caused. This results in the boiler pressure blowing the whole of the

water in the trap down into the column and gauge glass and should it be a "solid" column mounting, the whole of such water is sent into the glass, with the result that the level as shown is suddenly increased very much. Further the water already in the glass rises a trifle under the reduction of pressure in the top steam pipe and so to avoid false indications it is advisable to blow through the top steam pipe at such frequent intervals as will ensure its not becoming filled with condensed steam.

218 and 219. ALTERNATIVE SETTING.—You are looking at the water gauge and suddenly see the level rise considerably, what is the cause of such? After blowing through the glass why should the level be different to what it was before the blowing?

Ans.—(Those already given will do.)

220. Describe your method of thoroughly testing the water gauge system to satisfy yourself that all cocks and pipes are clear. Your answer can be written on a supplementary sheet of foolscap, which the examiner will hand you. Hand sketches, mere lines indicating pipes and circles indicating cocks, should be made. Identify the cocks and pipes by letters or numerals.

Ans.—When going to blow through a glass water gauge fitted on a hollow column, to prove it being in working order or otherwise, the first rule to remember is "double shut off what there is in the glass." If the steam end be tested first, then shut off both the cock or valve at the boiler where the lower pipe joins it, cock No. 5 in the sketch made here, and also cock 3. The water end of gauge being now isolated, open the drain cock 4 and see if she blows through 1, the steam pipe, and cock 2. If so, that end is all clear. To prove the water end next, open up cocks 5 and 3, and close Nos. 1 and 2, and open 4 and if the water rushes out strongly it proves the water pipe as well as cocks 5 and 3 are all clear.

Next suppose we had found the gauge showing full water. Double shut off the water end by closing cocks 5 and 3, open 4 and if steam comes, it shows 1, the pipe, and 2 are clear and so the boiler is too full of water. Had no steam come on opening 4, open 3 next and if then steam blows through 4 it proves cock 2 is choked. Close No. 1 and take

out the cleaning plug and with a wire remove the chokage in cock 2. Replace small plug and try steam end again by opening up 1. If, however, even after opening cock 3, there is still no steam through 4, it shows the chokage is either in steam pipe or at cock 1. Break the joint where the steam pipe is attached to the cock or valve chest, first closing this and slowly open No. 5 and see if water can be blown right through; if so, the pipe is clear. Assuming it to be so, the stoppage is at 1. If this be a cock, try inserting a stiff piece of bent wire in the hole as the plug of the cock is slowly opened, and standing clear, one may be able to loosen the obstruction when the steam pressure will

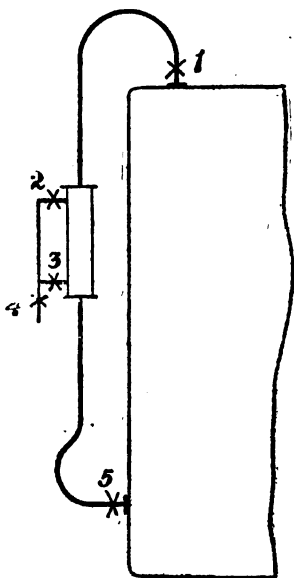


FIG. 82.

carry it clear. The pipe, etc., can be rejoined and the gauge tried through when all will be well. If No. 1 is a valve, one will have to work off the steam from the boiler and take the whole valve, etc., adrift and clear it properly.

If the glass be found apparently empty, *i.e.*, full of steam, double shut off the steam end by means of Nos. 1 and 2 and open the drain 4, and if it blows water it shows the water end is clear and the level in boiler is dangerously low. The fires should be checked by wet ashes thrown on them and the dampers closed, or fan stopped and the donkey got to work pumping up the boiler.

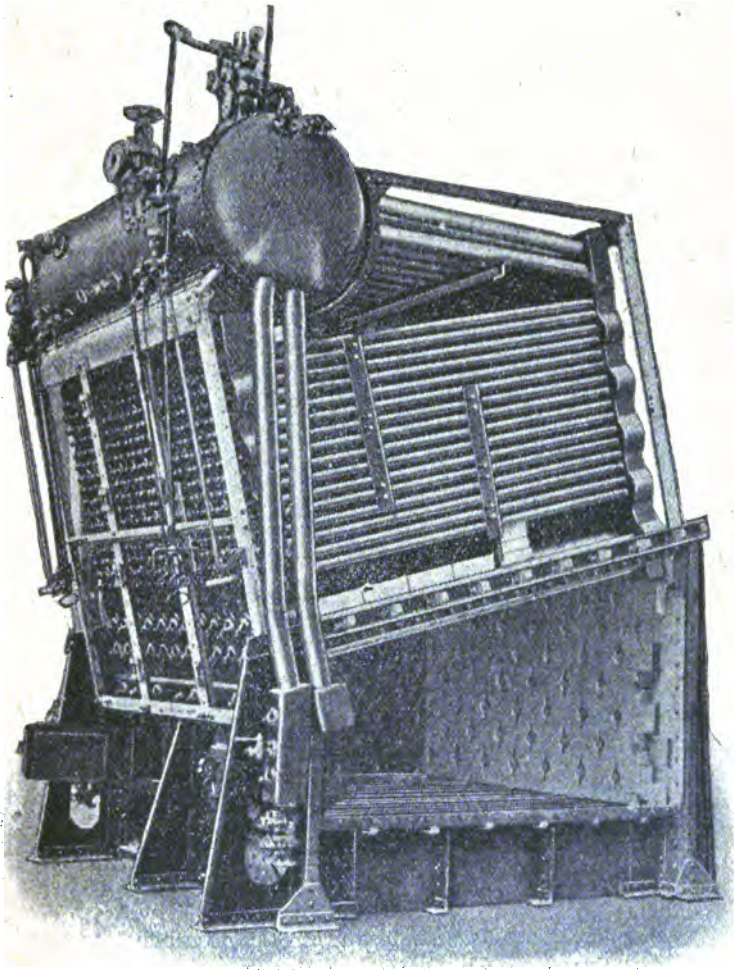


FIG. 83.

221. Describe the construction of a water tube boiler, mentioning the type selected.

Ans.—A Babcock & Wilcox is one of the best examples of a modern "large tube" water tube boiler. It consists of an arrangement of tubes inclined at 15 degrees to the horizontal, which form the bulk of the heating surface, sinuous-shaped boxes or "headers," and to which the tubes, either in groups of four small or one large one, are fixed by expanded joints. A horizontal steam and water drum running above the front headers, and to which it connects by short tubes, a mud drum, and a furnace of large capacity below the inclined generating tubes.

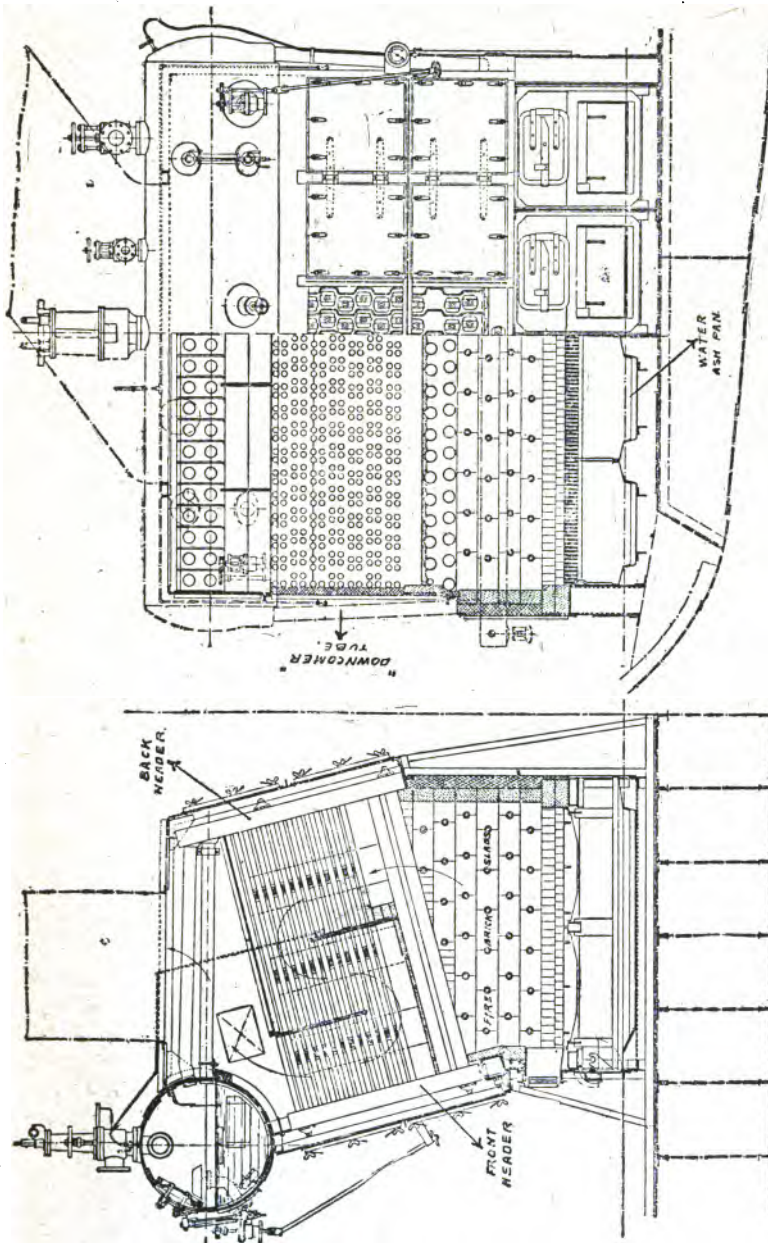
The back headers are connected to the steam and water drum by large diameter horizontal tubes, which enter the drum just above the normal water level. Below the front headers is placed a square section tube or box, and each header connects to this by a short piece of tube or "nipple," and this square tube serves as a blow off or sediment box, through which the boiler can be completely drained.

The steam and water drum carries the usual mountings, such as safety valves, water gauge, stop valve, etc., etc., and is fitted internally with "wash" plates to prevent undue movement of the water as the vessel rolls and pitches.

All parts are of steel, and the entrance to the tubes in the headers has opposite to it a small handhole and door by which every tube can be examined and cleaned. The furnace is built round with fire brick slabs, and the whole boiler is covered with sheet steel lined with asbestos; that is all bar the steam and water drum. The circulation in these boilers is as follows:—The heated water and steam flow up the tubes to the back headers and thence by the horizontal tubes return to the drum, wherein the steam is liberated finally, and the water, passing down the front header, goes to the tubes to be in turn heated.

222. In a water tube boiler how is an economiser fitted, and what is its duty?

Ans.—In some forms of water tube boilers, notably the "Belle-ville" pattern, there is placed in the uptake a miniature edition of the main boiler, and this is the economiser. It consists, with this type, of a series of small tubes inclined and screwed to return bends at each end, the whole forming a zig-zag "element," several of which "elements" placed side by side form the economiser. Along the



BABCOCK & WILCOX MARINE-TYPE BOILER

FIG. 84.

bottom front the lowest tubes connect it to a feed water pipe, and at the top the highest tubes connect to a similar pipe running across them, and which receives the heated feed, sending it thence to the steam drum of the main boiler. As the economiser is surrounded by the waste gases of combustion, the feed water circulating through the zig-zag piping becomes heated, and thus an "economiser" is only a feed heater, but is one not using steam as the heating agent.

222. ALTERNATIVE SETTING.—What form does a feed heater take when built as a part of a water tube boiler? What is the particular part called?

Ans.—(That already given will do.)

223. How is the water gauge fitted in a water tube boiler? Are glass gauges used?

Ans.—In such as the Babcock & Wilcox boiler two glass water gauges are fitted, one towards each end of the steam and water drum. They connect direct to this, there being no "hollow column" and no internal pipes. Often the gauges are of an automatic type, such that if the glass breaks, steam and water are shut off by the actual rush carrying a ball or other valve against a specially prepared seat, so that it blocks the orifice leading to the broken glass. Glass gauges are used, but are often of the "Klinger" pattern, wherein the water part shows black, whilst the steam portion shows silvery.

224. The pressure of the steam in water tube boilers is sometimes greater than at the engines. Why is this, and what percentage above the engine pressure does it amount to? How is this difference of pressure maintained?

Ans.—It is beneficial to produce steam in the boilers at from 15 to 20% higher than is to be used by the engines, because by employing a "reducing" valve, which once set for the desired reduced pressure upon its outlet or engine side automatically maintains that pressure, prevents such variations in the steam in the boilers as might be occasioned did the engines draw direct from the very small reservoir or

steam space a water tube boiler possesses. In addition to keeping the pressure at the engines more even, a reducing valve, by slightly throttling the steam, causes it to become drier, because the drop in temperature and consequently thermal units between the inlet or high pressure side and the outlet or low pressure one all goes to evaporate some of the moisture the boiler steam contained, as though the pressure falls at the reducing valve, no *work* is done by the steam thereat.

224. ALTERNATIVE SETTING. — What is a reducing valve? How does it act? What effect has it upon the steam other than altering its pressure? Why generate steam at greater pressure than is needed by the engines?

Ans.—A reducing valve is a spring controlled throttle valve, which is opened by compressing a spring to such an extent that when the steam from the inlet, or high pressure side, has passed the space between the two mitres and so reached the outlet (or low pressure side), the pressure there is *less*, and as no *work* is done by the steam in passing the valve the drop in temperature results in some of the moisture being dried out of the saturated inlet steam. Thus, a reducing valve is a steam dryer as well as a pressure reducer. It is to obtain this drying effect as well as to combat the fluctuations in pressure which would result in a quick revolution engine and a boiler of small steam space that such valves are employed.

Figs. 85 and 86 show one of Auld's "Quitetite" Reducing Valves. Fig. 86 shows clearly the spring and lever for opening the valve, while fig. 85 gives a sectional view.

High pressure steam enters at "INLET," acting between valve (4) and piston (16), both of the same area, and $\therefore$ in equilibrium on this high pressure side. Reduced pressure is got by screwing up adjusting nuts (21) until pointer (24) is opposite the figure denoting the required low pressure. Acting through lever (15) the extension of spring (26) opens valve and steam at reduced pressure passes to outlet side, and when the pressure here tends to rise above that required it closes down the valve a little by acting on its back and the chamber (17) through passage (20). When the pressure tends to fall the tension on spring overcomes the force holding valve down, and so opens this out

again, allowing more steam to pass to the low pressure side, and in this way the pressure is kept even. A flexible diaphragm (10) makes

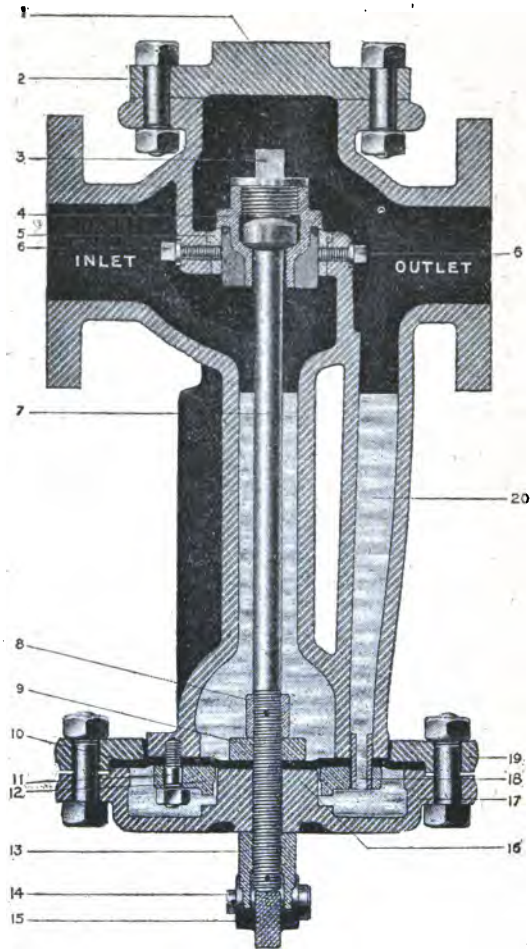


FIG. 85.

a frictionless steam-tight packing, and is protected from the action of the steam by the water of condensation collecting in the lower parts.

Fig. 87 shows one of the ordinary type of Auld's reducing valves, and the great difference between it and that shown in figs. 85 and 86

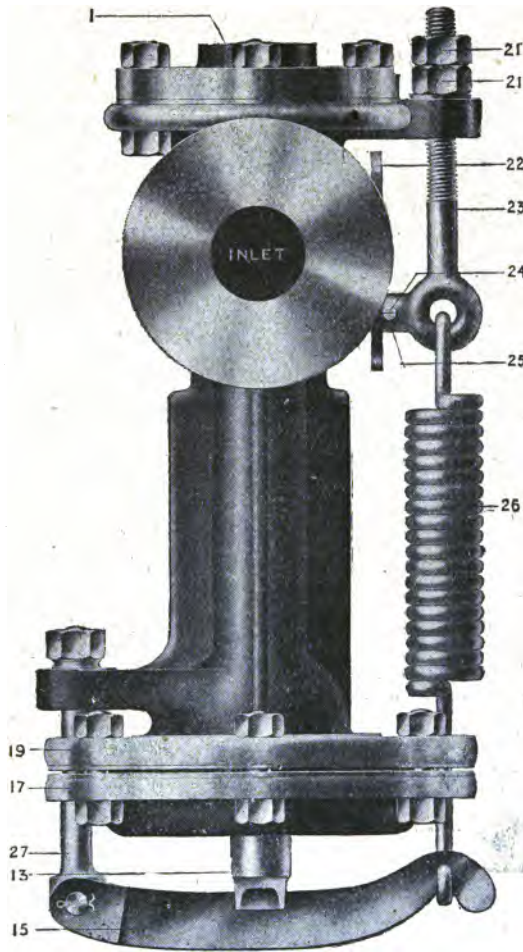


FIG. 86.

lies in the greater controlling force of the "Quitetite" pattern in which the area open to the lower pressure is six times the area of the back of valve, and so a rise in pressure of only one sixth that needed with

fig. 87 closes down the valve, and this makes the "Quit-tite" a much more accurate working valve.

We show the older pattern because many steamers carry it, and candidates must understand its construction.

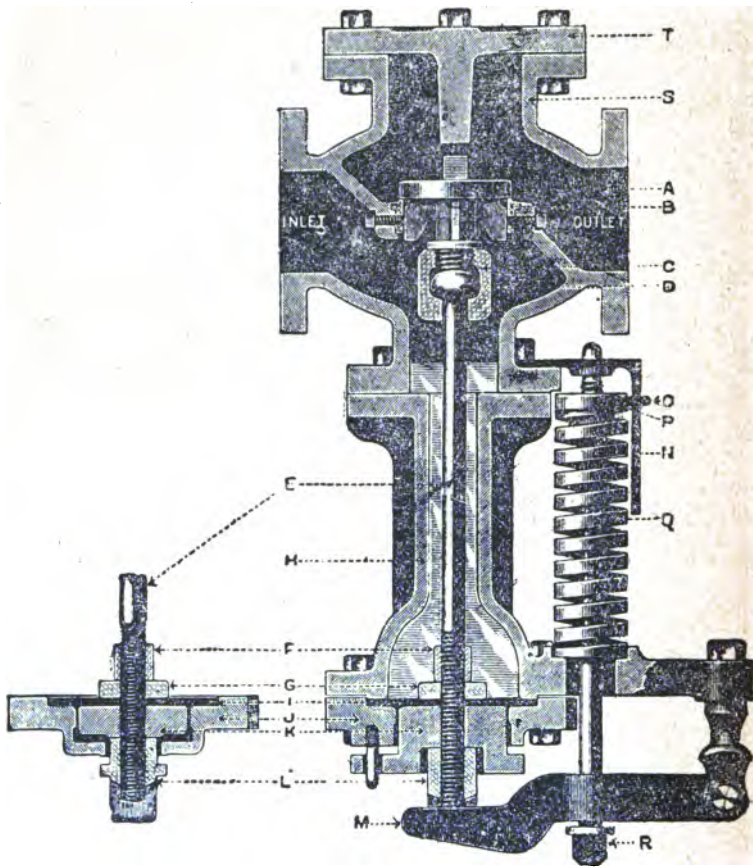


FIG. 87.

225. Describe any automatic method of feeding water tube boilers. Of what material are the tubes made?

Ans.—The automatic regulator as fitted to Babcock & Wilcox water tube boilers consists of a hollow cylinder fitted just outside the steam and water drum, and parallel thereto, and which cylinder works in a

liner fitted to a containing case bolted to the drum, being rotated for a certain amount of a revolution by means of a float and lever placed inside the drum. The cylinder has diagonal ports along its walls, and the liner it works in has corresponding ports. The containing case has two branches, one for a check valve and the other for a pipe leading to

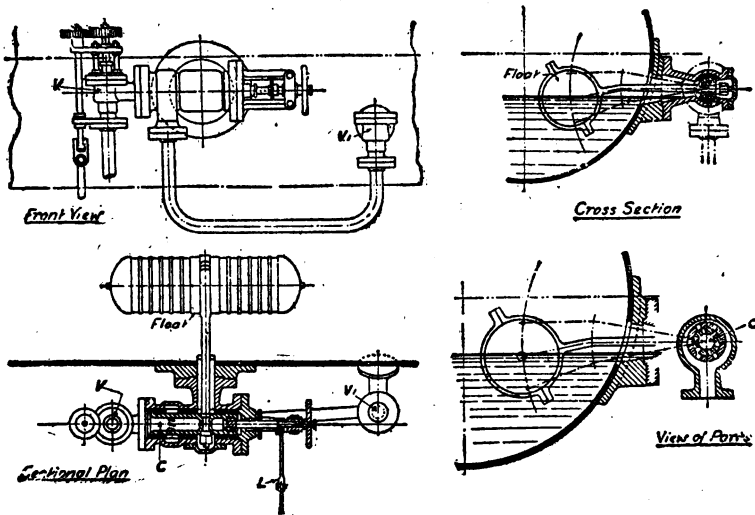


FIG. 88.

the check valve on drum. The action is as follows:—The feed enters by check valve *V* on regulator casing and passes to the hollow cylinder *C*, and if water in drum is low it goes through the diagonal ports, which will then agree with one another, and so on to the main check valve *V*₁ and into the drum. As the water rises it carries the float up, and so turns the cylinder and the ports become partially closed. Thus, when the level is high in the drum only a very little feed can pass, and *vice versa* when the level is low.

The tubes in all water tube boilers are made of the best quality mild steel, solid drawn, and sometimes they are of nickel steel.

225. ALTERNATIVE SETTING.—With a water tube boiler what requires very careful attention? Is anything fitted to perform this automatically, and if so describe a form it often takes?

Ans.—The principal point requiring attention about water tube

boilers is to see that the feed supply is kept up without a break, as the amount of water in these boilers is so small that even a few moments' interruption of the feed may lead to damage, and, to assist in so maintaining the supply, what is called an "automatic feed regulator" is usually fitted. (For the remainder of this question the answer already given will do.)

226. Describe the construction of any steam turbine you are acquainted with which is used on board ship. How is the expansion of steam effected? How many propeller shafts are employed, and how many propellers?

Ans.—The essential feature of the Parson parallel flow turbine is a shaft carrying a steel drum upon which a series of blades or vanes radiate out. These are arranged in grooves and form rings of blades, each blade being slightly curved across its breadth. This drum revolves

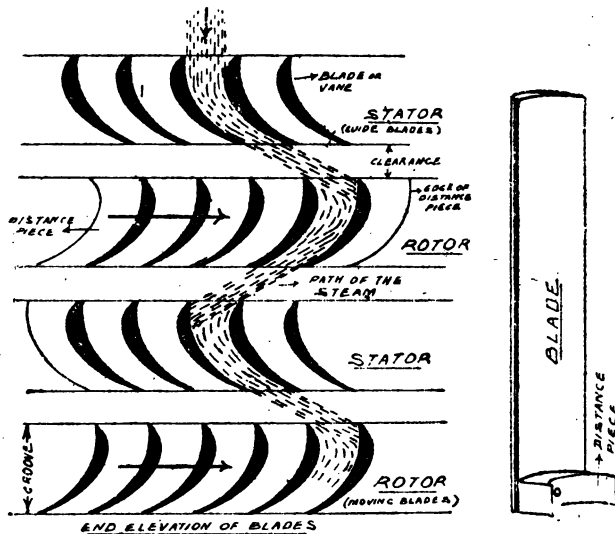


FIG. 89.

within a fixed casing or "stator," the inside of which carries a similar series of blades fixed in grooves and so arranged that each ring of stator blades project down into the space between two rings of the moving blades on the "rotor." Steam being admitted at the high pressure end

of the casing, or stator, comes in contact with the first row of the fixed vanes and is guided by these and made to impinge upon the first ring of moving blades (see fig 89), which yield to the impact and move round, subsequently working past these and being received by the next set of guide or fixed vanes and deflected by these on to the next moving set, and so on right through the whole turbine. At the entrance end all blades are short and remain so for a certain number of rows, then a series of longer, broader, and flatter blades are met, these in turn becoming still longer, etc., as each definite stage of the expansion is met, and at the same time the clearances between blade tips and casing, or rotor, and that between adjacent rings of blades, which were fine at the high pressure end, become greater as each expansion comes along, thus the necessary increase in volume is obtained to suit the expansion of the steam as its pressure drops in working through the turbine.

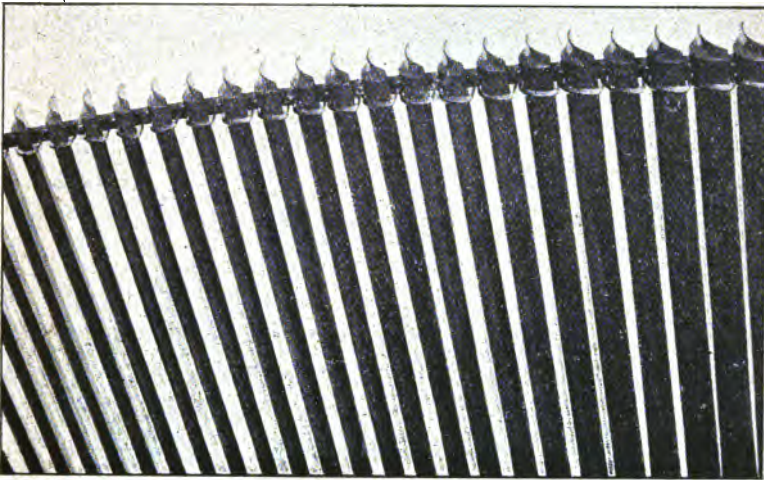


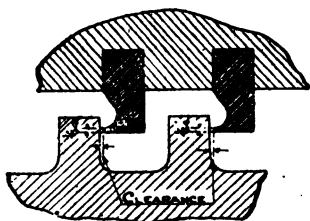
FIG. 90.

[This figure shows the blades in position and secured at the ends by the binding wires, and it also shows the tips of blades thinned off, so that should they accidentally come in contact with the casing this thin edge merely bends over and the blading does not experience such a tendency to be dragged out of its groove in the rotor.]

In a definite high pressure turbine there are usually about 4 or 5 expansion stages, and in a low pressure turbine there may be about 6.

The turbine shaft is either coupled direct to propeller shaft or else carries the pinion wheel if a "geared" set of turbines is installed.

Taking the former, the thrust from the screw is balanced as follows :— Forward of the steam inlet is fitted a drum having a series of grooves turned in it, and from the casing there projects down into these grooves, with a minute clearance (see fig. 91), brass rings whose object is to prevent the steam escaping and to offer the reaction necessary to balance the thrust. Thus, the steam presses aft on the blades but requires something to confine it and so let it exert its pressure, and this is obtained by the above described “dummy” piston. As the thrust of the screw acts forward, the thrust of the steam *via* the blades acts aft, and so the one balances the other. Any unbalanced thrust as may be met when steam is just shut off, or opened up, is taken by a small thrust block fitted forward of the main turbine. The shaft passes



CONTACT DUMMY STRIPS.

FIG. 91.

through the casing by what are called “steam glands,” consisting of a number of rings projecting into corresponding grooves turned in that part of the shaft, and as the clearance is very small the steam in its effort to leak past falls to the atmospheric pressure, and so has no tendency to escape. The main bearings are much of the usual type and supplied with a forced lubrication.

There are usually three shafts fitted in average sized vessels, each carrying a single screw of rather small diameter. Large boats have four shafts, whilst a “geared” installation has only one, and its screw is of the ordinary diameter and pitch.

Note by Author.—Fig. 92 shows the modern development of turbine for vessels whose speed does not have to be so extremely high, but where it is still desired to take advantage of the economy of the turbine running at its own very high rate of revolution. In such vessels as cargo boats, etc., the propellers are of the usual size and turn about

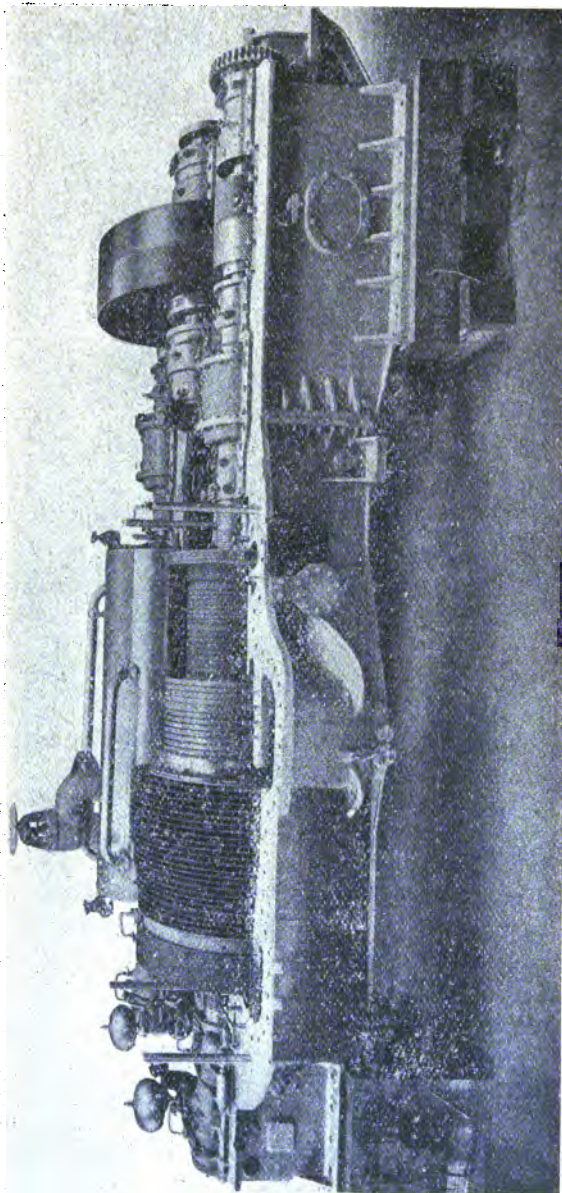


FIG. 92.

60-90 revolutions per minute, and to enable this to be obtained with turbines running about 1500-1700 revolutions per minute, gearing is resorted to as clearly shown in the figure. The turbo shaft carries the small, or pinion, wheel gearing into a very much larger wheel fastened on the propeller shaft, and a common reduction ratio is about 1 : 25. The figure shows the low pressure and reverse turbines opened out, and that seen in the background is the high pressure, and as the complete set forms one of a pair (the particular vessel being twin screw) it is seen there are two "reverse" turbines, but four are available for headway propulsion.

Plates VI. and VII. also show the arrangement of the several parts of turbine, and the following is a brief reference or key to the letters on these plates :—

PLATE VI.

- A Stator or casing.
- B Rotor.
- C "Dummy" casing and balance piston.
- D Main bearings.
- E Thrust and adjusting block.
- F Glands (steam packed).
- G Worm for governor.
- H Exhaust to low pressure turbine.
- I Steam inlet.
- J Turbine drain
- K Oil inlet.
- L Oil drain
- M Bye pass connections.
- N Boss for relief valve.

PLATE VII.

- A Stator.
- B Rotor.
- C Ahead balance piston.
- D Astern balance piston.
- E Bearing.
- F Thrust and adjusting block.
- G Steam packed gland.
- H Worm for governor.
- I Steam inlet from H.P. turbine.
- K Astern turbine steam inlet.
- L Exhaust to condenser.
- M Low pressure manoeuvring steam inlet.
- N Turbine drain.
- O Oil inlet.
- P Oil drain.

It must be remembered that at the present day (1916) details change fairly fast, and turbines are undergoing modifications and improvements in many respects, as, for example, a common style of up-to-date packing is to have rings of carbon held in position by springs on somewhat similar lines to ordinary metallic packing for piston and slide rods of a reciprocator. Such carbon packing replaces the "steam packed" gland.

Plate VIII. is a general view of the installation of a twin screw geared turbine vessel.

226. ALTERNATIVE SETTING.—Wherein does a turbine differ from a reciprocating engine? What benefits does a turbine possess? Can they be used in every class of vessel?

Ans.—The chief advantage is in having no dead centres, as the

PLATES VI. AND VII.

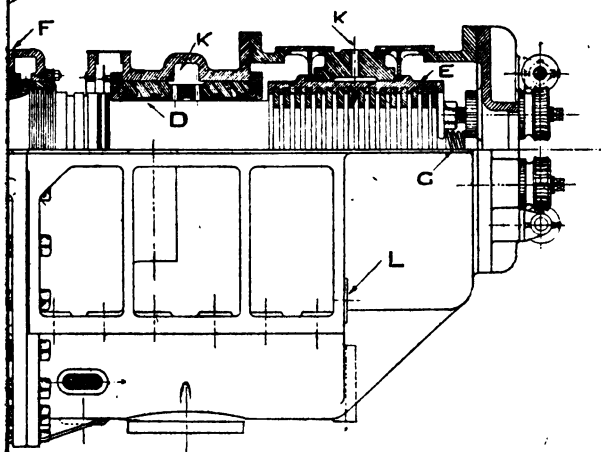
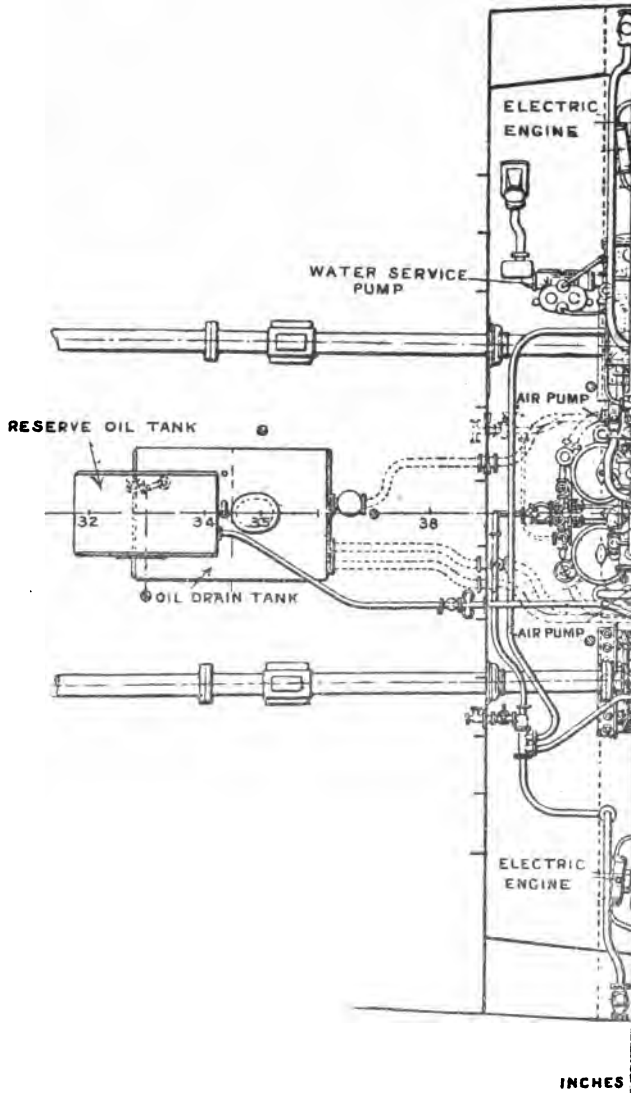


PLATE VIII.



To face page 179.

motion of a turbine is continuous rotation. Also, there being only the two bearings, and those running with forced lubrication suffer *very little* wear down, and in consequence last much longer than with a reciprocator. The vibrations familiar with an inverted engine are absent, and if the turbine rotor is properly balanced there is little general vibration.

If the turbine is coupled direct to the screw shaft they are not economical for slow speed cargo vessels, because a turbine should revolve at a quick speed, while the propeller should turn slowly for maximum efficiency, but by the introduction of gearing it is possible now to let the turbo run at its high speed, and gear *down* on to a large wheel upon the screw shaft.

227. Is the same power in a steam turbine available to go astern as to go ahead?

Ans.—Not as a rule is there as much sternway as headway power available, because in the average vessel only the two wing shafts carrying the low pressure turbos will have sternway turbines fitted, and though these are supplied from the boilers, when the headway steam is shut off, yet being smaller and less in number results in the astern power being a good deal less than the headway. These remarks do not apply to warship work where the sternway power is much greater in proportion.

228. Of what material are the propellers made in a steam turbine?

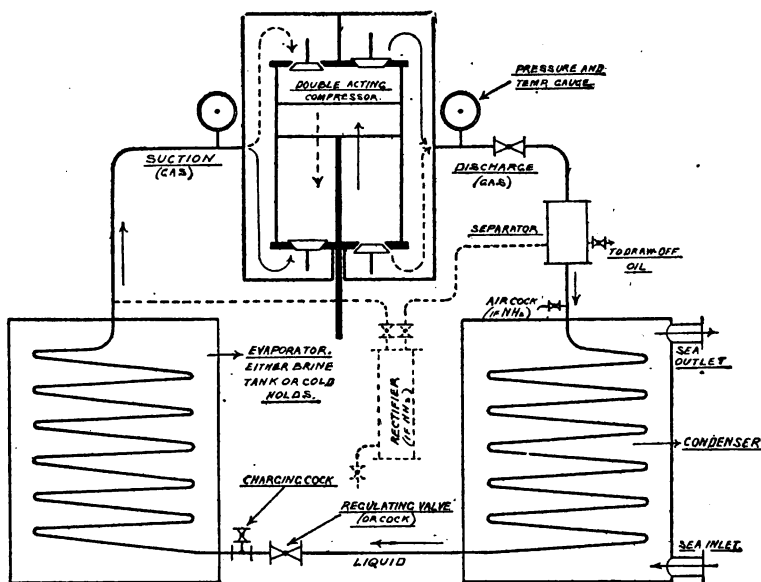
Ans.—Phosphor or manganese bronze is a favourite material as it combines great strength and ductility with a fair measure of lightness.

229. How many lbs. of coal per indicated horse power per hour are burnt with turbine engines? Name the type of boiler in use.

Ans.—As one cannot take the *indicated* horse power of a turbine, resource must be had to what is called the shaft horse power and the consumption is usually given on this basis. For a geared turbine the coals are about 1·7 lbs. per hour per shaft horse power and for the ordinary installation in average high speed vessels it runs about 1·5 to 1·7 lbs. at full power. Ordinary cylindrical or Scotch boilers are largely used, but at the present day, and always in the Navy, water tube ones are fitted.

230. Describe one of the several classes of refrigerating machinery in use on board ship. Several types exist, one being more economical than the rest. Which is it?

Ans.—Which class of freezer is the most economical is a moot point, but it is often held that the NH_3 or ammonia system is the premier, but the CO_2 or carbonic acid gas one runs it very close and may under some conditions be actually superior to the NH_3 . Taking the ammonia process the actions are as follows:—The machine having been charged by attaching the steel bottle containing the liquid NH_3 to the “charging cock,” the compressor raises the pressure to anything from 150 lbs. to 250 lbs. per square inch depending on the temperature



THE ABOVE IS TYPICAL OF THE ESSENTIAL FEATURES OF BOTH CO_2 AND NH_3 PLANTS.

FIG. 93.

of the sea. The hot compressed gas goes then to a “condenser” supplied with sea water and wherein by abstraction of heat the NH_3 becomes a liquid. From the condenser this liquid goes to the “evaporator,” passing on its way the “regulating” valve. In the evaporator it returns to its gaseous state by expanding and absorbing heat from everything in the cold hold or the brine tank. After leaving

the evaporator coils it returns in a gaseous form to the suction side of the compressor and the cycle repeats itself.

230. ALTERNATIVE SETTING.—What is meant by a freezing agent having good efficiency? Which of the following is the best, cold air, ammonia, or carbonic acid gas?

Ans.—For a freezing agent to be really efficient it must absorb as large a number of thermal units as possible in its change from a liquid back to its original form of a gas. Ammonia needs about 555 T.U.s. per lb. to turn back to a gas while in the evaporator coils, whereas CO_2 only takes up about 124 T.U.s. per lb. NH_3 is therefore about $4\frac{1}{2}$ times as efficient as CO_2 . Air has no latent heat of evaporation as it does not liquefy, and in consequence much larger volumes and weights of the air must be dealt with to produce a desired cooling effect, because we can only deal with the drop in its temperature or sensible heat.

231. Describe the defects to which the selected type is subject. How are the defects overcome?

Ans.—With an ammonia plant the two serious defects are first, if the gas escapes into contact with the cargo this may be spoilt, and, second, that no copper or brass must be allowed anywhere in contact with ammonia, as this exerts a destructive effect upon anything containing copper. Therefore all valves, cocks, etc., where ammonia passes must be of cast iron or cast steel; all coils, etc., to be of wrought iron or mild steel. To overcome leakage spoiling cargo, pay instant attention whenever the nose detects a leak of NH_3 in a part of the hold pipes. Burning sulphur near the suspected part will when the escaping NH_3 meets the sulphur cause a discoloration in its fumes.

With a CO_2 plant about the only drawback is the one of possible leakage at the compressor valves, piston rod gland or piston leathers, due to the very high pressure. If the latter, generally new leathers have to be fitted, and if the gland leaks it may be stopped by screwing up a little, otherwise new packing must be fitted. With leaky valves the remedy is to regrind them.

232. How frequently are the parts opened out for examination? Name the parts.

Ans.—It is customary to overhaul the freezer machines on the out-

ward run of the vessel, or in port after the cargo is removed, should time permit. If possible all such as compressors, etc., should be overhauled, say, about every month or 6 weeks, and about every 6 months overhaul the condenser and evaporator.

233. How frequently are the condensers of refrigerating plants opened for examination? How frequently are the coils tested by hydraulic pressure? On which side of the coil is corrosion most commonly found? Why should this be so?

Ans.—The condenser and evaporator coils should be opened up and inspected, if possible at about six months' intervals, but a hydraulic test is not advised.

Compressed air up to about double the working pressure is much better, as there is then not so much moisture to remove from the inside of the coils, as would be the case with a water test. If bubbles of air are seen escaping when the coil under the air pressure is placed in a tank of water we know where the leak is by tracing back to their origin.

Coils usually corrode on the out or water side with an ammonia machine, as the wrought iron or mild steel is liable to a heavy corrosion from the sea water, but the copper coils of a CO_2 plant do not do so.

234. Where ammonia is used in refrigerating machinery, should the machinery by preference be isolated? Why? In reply give what information you possess bearing on the matter, naming the ships for purpose of identification.

Ans.—It is preferable to have the ammonia freezing plant isolated from the main engine room, because if an accident happens and allows the gas to pour into this latter it will most likely drive out all the occupants of the engine room. Ships often carry a diver's helmet and air pump which can be used to enable one to get at the broken down plant, but a hose vigorously played about the engine room will soon absorb the ammonia gas and convert it to the liquor NH_3 which can be pumped out. If the plant is isolated, however, the freezer attendant can escape and close off the chamber behind him.

Note by Author.—The latter part of this question must be answered or not just as the candidate may happen to have been with an NH_3 freezer and if there should have been any breakdown with this same.

234. ALTERNATIVE SETTING.—If ammonia plants be placed in the main engine room, what may result?

Ans.—(That already given will do.)

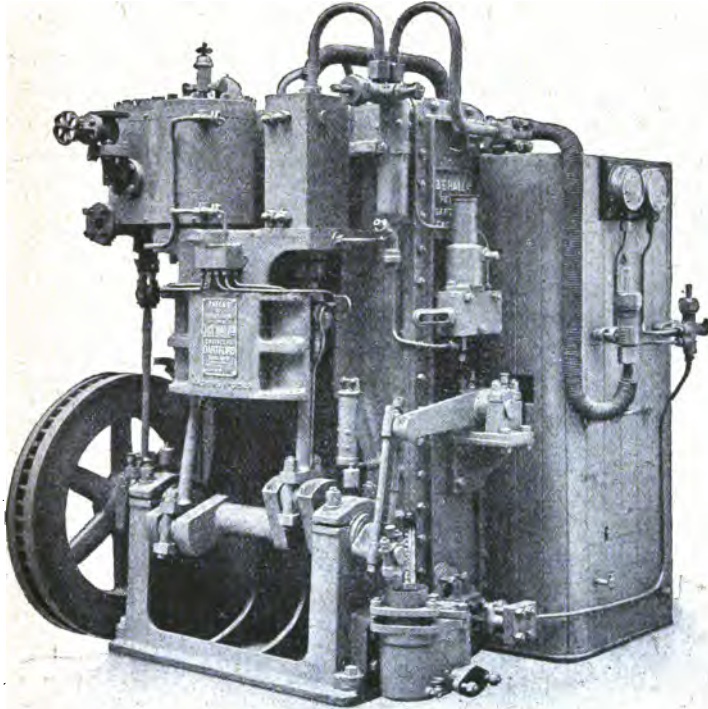


FIG. 94.—Hall's Vertical Single Marine Type CO₂ Freezer.

235. Explain how the ammonia is removed from the tubes in which it is supplied, and how passed into the refrigerating machine.

Ans.—When charging a new machine we must see that all air is got out of it, to do which disconnect the pressure gauge from the compressor discharge pipe, next close the valve upon the pipe leading to condenser coils (see fig. 86) and start the machine. The compressor acting as an exhausting air pump draws the air from all the condenser and

evaporator coils and so lowers the pressure. After a short time couple up the gauge, open discharge valve and then the bottle of NH_3 can be attached to the "charging cock" just before the evaporator coils, being suspended by a spring balance so that the weight of gas supplied can be noted. Close the regulating valve to keep pressure off bottle. By opening cock on bottle and charging cock, the ammonia will by reason of its excess pressure flow into the coils, being helped by the suction of the compressor. As the pressure rises upon the discharge side we obtain the knowledge as to when the plant is charged. The charging cock and cock on bottle are closed and regulating valve opened and the system is in working order.

Note.—One bottle will not be enough to charge a new machine, but the process is the same, however, many bottles being required to give the full pressure. Before removing a bottle close charging cock and re-open when the next bottle is attached.

236. What objection is there to the presence of water in the ammonia?

Ans.—As water is very greedy for ammonia (1 vol. water will absorb about 800 vols. of NH_3) it would absorb a lot of this agent and so the efficiency of the plant would fall. Also the water would form ice inside the evaporator coils and might in time entirely choke these.

237. Describe the ammonia process of refrigeration.

Ans.—Note by Author.—This has practically been answered by what was written for question 230, but in addition thereto a few details can be added to the candidate's answer to this question (237).

With an ammonia plant there are fitted both an oil collector and a rectifier. As the hot compressed gas leaves compressor, it goes to the oil collector in which the oil falls from it and the gas passes to the condenser. From the collector the oil is taken to a rectifier in which any ammonia gas it may have is drawn away by the suction side of compressor being connected to the rectifier, the oil being periodically drawn off.

238. Of what material are the parts made which are in contact with the ammonia?

Ans.—Only iron or steel such as wrought or cast iron, cast or mild

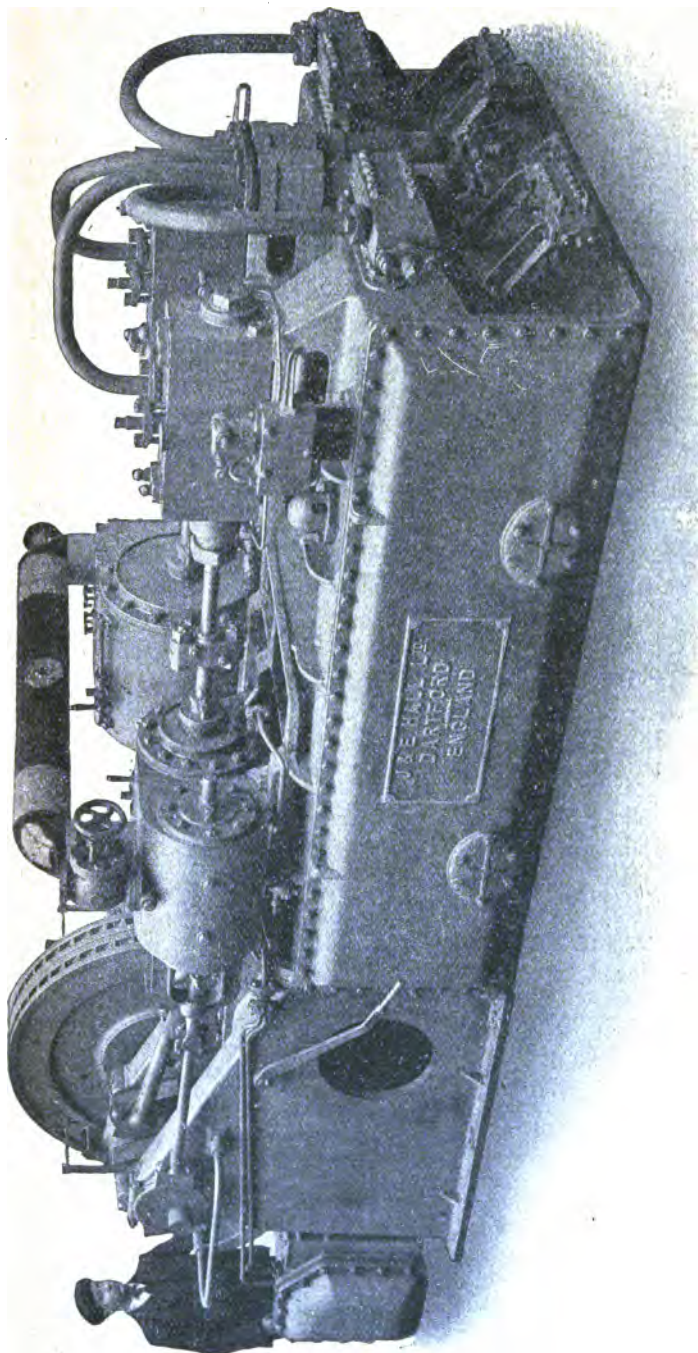


FIG. 95.—Hall's Horizontal Duplex CO₂ Freezer.

steel must be used, as nothing having copper in it will withstand ammonia. Should copper be present, corrosion occurs leading to its destruction.

238. ALTERNATIVE SETTING.—Is white metal allowable in places where ammonia is present? Is copper?

Ans.—No copper is allowed as the ammonia turns it to a more or less spongy green mass and therefore no white metal is permissible as this contains a certain amount of copper.

239. Are escape valves fitted to the compressors of ammonia machines?

Ans.—Not as a rule owing to the gas being such that it does not do to allow it to escape in any large quantities where there is human life. If an escape valve can be fitted with a gas tight hood and pipe leading the NH_3 clear, then escape valves could be fitted.

240. What is the maximum pressure found in the compressors of ammonia machines?

Ans.—The pressure at which the plant works depends on the temperature of the sea circulating water, but about the highest pressure is 250 lbs. per square inch, and for which the sea would have to be about 95°

241. What kind of pressure and other gauges are used in ammonia machines?

Ans.—The pressure gauges are marked in lbs. per square inch, on one scale of figures and on the second scale, marked in red, are given the temperatures equivalent to the pressures they are opposite. Two such are usually fitted, one on the delivery from compressor and the other on the suction side, recording the pressure on leaving evaporator coils. The tubes and connections to these gauges must be of steel to avoid corroding. Thermometers or temperature gauges should be fitted to inlet and outlet of the condenser to note the amount of heat abstraction by the circulating water.

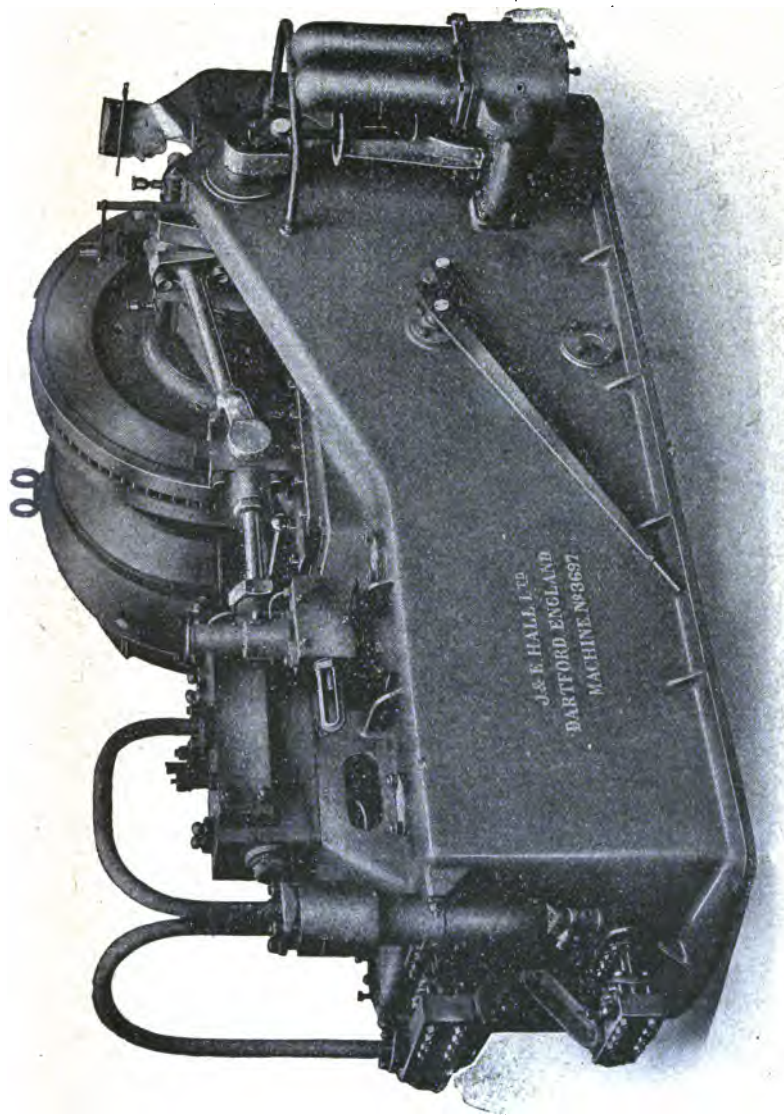


FIG. 96.—Hall's Electrically Driven Horizontal Single Type CO₂ Freezer (Slow Speed Motor).

- 242. Explain how carbonic acid is removed from the tubes in which it is supplied, and how passed into the refrigerating machinery.**

Ans.—The CO_2 bottle (or tube) is suspended valve downwards from a spring balance recording its weight. The valve is connected by a copper pipe to the charging cock on machine just before the evaporating coils and on opening both valve and cock, the CO_2 , by reason of being at a higher pressure, passes into these coils and so to the compressors. It is necessary to close the regulating valve beforehand in order to keep the pressure off the bottle, and to get as much of the gas out as possible hot water is poured over the bottle and assists in driving out the gas.

During this process of charging, it is necessary to run the compressor as an exhausting pump, drawing from the evaporator coils and so "pumping down" and reducing the pressure enables the CO_2 to more readily pass to the system. (*Note by Author.*—See answer to Question 235.)

- 243. What objection is there to the presence of water in the carbonic acid?**

Ans.—The water would form ice inside the evaporator coils and so choke them and lower the efficiency of the system and also some of the gas would be absorbed by the water.

- 244. Describe the carbonic acid process of refrigeration.**

Ans.—A carbonic acid gas freezing plant consists of three important parts, or divisions, viz., the compressor into which the gas is drawn from the evaporator and compressed up to from 900 to 1200 lbs. per square inch. The condenser, consisting of coils of copper pipes immersed in a tank through which sea water circulates and the hot compressed gas entering these at the top is by abstraction of its latent heat converted to a liquid, whence it issues from the condenser and passing the regulating valve goes to the evaporator coils, either in the holds or else in a brine solution. In these evaporator coils the liquid CO_2 returns to its gaseous state by absorbing heat from everything there is surrounding them and this lowers the temperature to as much as 80° below freezing point, if needed. When brine is used it is circulated through the pipes in the hold by a special brine pump, and with this method a less charge of CO_2 is required than with the direct expansion system, which is the one where the evaporator coils themselves are in the holds.

245. Of what material are the parts made which are in contact with the carbonic acid?

Ans.—They can be made of copper, brass, iron or steel, as CO_2 has no destructive effect upon copper. The compressors of Messrs. Hall's machines are made of solid steel forgings bored, or else are cast in a special bronze. The condenser coils are either of wrought iron or copper.

246. Are escape valves fitted to the compressors of carbonic acid machines?

Ans.—Yes, because this gas is not so harmful in moderate quantities to human beings as is ammonia gas. The escape valve is a

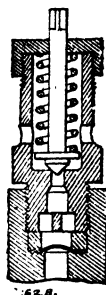


FIG. 97.

small, spring-loaded valve protected below by a thin disc of copper which must be burst through by the excess pressure before the valve can lift.

247. What is the maximum pressure found in the compressors of carbonic acid machines?

Ans.—The maximum pressure is about 1200 lbs. per square inch and this would be required for a sea-water temperature of $\frac{1200}{15} = 80^\circ$.

247. ALTERNATIVE SETTING.—If the sea water rose 10° , how much would you increase the pressure with a CO_2 plant? Why is an increase of pressure necessary?

Ans.—As the pressure increases about 15 lbs. per 1° rise, there

would be $10 \times 15 = 150$ lbs. per square inch more. The reason is that the sea water which circulates through condenser must always be lower than the temperature of the gas, and therefore if the water rises we must increase the pressure and consequently the temperature of the gas, so that it may still be higher than the water, as if not, the latter cannot extract enough heat from the former so as to liquefy it.

248. What kind of pressure and other gauges are used in carbonic acid machines?

Ans.—The pressure gauges are of the same construction as what are used for steam, only the scale of pressures is marked off in "atmospheres," *i.e.*, divisions of 15 lbs., and it should go as high as about 90 atmospheres. They have a scale of temperatures corresponding to the particular pressure. One gauge must be fixed on the delivery pipe from compressor, and the other, which need not have such a high limit, is fixed on the suction side. Temperature gauges for inlet and outlet from condenser should also be fitted to record sea temperature and temperature of discharge.

249. In which type of machine is brine used? What is its density? Where does it circulate?

Ans.—Brine can be and is used with either CO_2 or NH_3 machines, and in both cases consists of a solution of common salt (chloride of sodium) or else chloride of calcium (lime); the latter is better as it does not cause such heavy corrosion of the iron evaporator coils as does the salt solution. The specific gravity of a brine solution should be about 1.25, or 1 gallon should weigh $12\frac{1}{2}$ lbs. instead of the 10 lbs. weight of 1 gallon of fresh water.

249. ALTERNATIVE SETTING.—About what difference in temperature is there in the incoming brine over the outgoing? If the brine solution be made with common salt (chloride of sodium) what should be added to minimise corrosion?

Ans.—The difference in the two temperatures ought to be only a few degrees, say about 4° to 6° . If the liquor be formed with ordinary salt, add 1 lb. of caustic soda to every 100 lbs. of the chloride of sodium used.

250. Are fans for circulating air used in any of the refrigerating processes? If so, why are they necessary?

Ans.—If the freezer installation is upon the "Battery" system, fans are employed as follows:—The evaporator coils of either the CO_2 or NH_3 machines are placed in a special room or chamber before the holds are reached and electrically driven fans force air over all these coils and along trunks to the holds in which the chilled air is distributed, and by absorbing heat in the ordinary manner becomes warmed and is led back to the suction of the fans. The main advantage of this system is that the moisture of the air as it freezes deposits in this special chamber and not upon the cargo and this is very beneficial with fruits, etc.

Note by Author.—The following is a brief description of a modern cool air system of keeping fruit holds at a moderate temperature. The evaporator coils arranged in a brine tank cool this down, and the liquid is then sent by a brine pump to the air cooling grids formed of wrought iron pipes situated in such places that electrically driven fans can circulate air over the grids, and the chilled brine absorbs heat from this air, which is then driven along trunks and discharged into the fruit compartments by a system of adjustable "louvres," being afterwards drawn to the fans through other louvres and trunks on the opposite side of the ship. The fruit spaces are insulated with granulated cork, and are so arranged in divisions that a continual circulation of the cold air is ensured about the sides as well as above and below the bins in which the fruit reposes.

250. ALTERNATIVE SETTING.—What is meant by the "Battery" system of refrigeration? What advantages has it? What kind of cargo needs such a method?

Ans.—(That already given will do.)

251. What means are in some cases employed for ascertaining the temperatures of refrigerating chambers without entering them?

Ans.—Long pipes very similar to sounding pipes are fitted to the holds, and their mouths where they reach the deck are closed by a brass plug screwed into a brass casting sunk flush with the deck. To the plug is attached a cord carrying a thermometer and this should hang so that its bulb is clear of the bottom of the pipe down in the hold.

When unscrewing plug and lifting thermometer to note its reading, do so and replace again as quickly as you can in order to avoid too great a rush of heat into the hold.

Note by Author.—In the following paragraph is outlined a good modern system of controlling hold temperatures worked with a carbonic acid gas machine, but ammonia can be used on the same principle. The evaporator coils are placed in a smallish tank of brine, and by the liquid CO_2 evaporating this brine is cooled to a very low temperature, and is known as "freezing brine." Another brine tank acts as a reservoir, and having all the returns from the various coils of piping or grids, which are placed in the cold holds, led to it, the brine within is at a fair temperature; in fact, is warm in comparison with the other. From this reservoir three sets of mains lead to suction valve boxes for the brine pumps, one suction being known as the "freezing brine" one, and which supplies the first mentioned brine tank above; other suctions are called the "thawing brine" and the "chilled brine." The freezing brine issues from its tank fit to circulate through the grids in the holds and bring their temperature as low as desired, perhaps down to 15°F . But it is not necessary to always have holds at such a low degree, and so the chilled brine service is brought into use and goes direct to the hold grids, whereby the temperature of the holds can be kept at, say, 30° to 40°F . by "attemperating," which consists in allowing a small quantity of freezing brine to mix with the larger quantity of chilled brine at a special mixture valve having a thermometer upon its discharge. By the fine adjustment of this valve, brine at an exact temperature suitable for abstracting just so much heat from the hold and contents can be obtained. The third or "thawing brine" set of mains allows brine to be drawn from the reservoir, sent through a steam heater, and then into the grids, the freezing and chilled brines having, of course, been first shut off. This hot brine heats up the grids and holds after they have been washed down, and dries the whole place ready for the next cargo.

252. What effect may the swabbing of the compressor piston rods have upon the working of refrigerating machinery?

Ans.—Any effect on cargo from swabbing compressor piston rods is only of importance with cold air machines, these being the only ones where the actual freezing or cooling agent comes into direct contact with the cargo. As the compressed air is at a high temperature, it is

quite possible that a slightly burnt smell may come off from the oil used in swabbing and which most likely will taint the cargo. In an NH_3 machine there is a tendency for the ordinary lubricating oils to form a species of emulsion by contact with the ammonia.

253. What is a rectifier? Explain its use.

Ans.—This consists really of a drain tank to receive the oil, and any ammonia it may contain as it comes from the “oil collector” of an NH_3 machine. The oil having congregated in the bottom of the collector is led to the “rectifier” and a pipe leads from this back to the suction side of the compressor and thus the gas is induced to pass away from the oil, resulting in a purifying of this latter and a saving in ammonia. A cock is fitted between the collector and rectifier and worked by special gear, as it is only at periodical intervals that the oil and ammonia from the collector should pass to be rectified.

254. Describe the cold air process of refrigeration.

Ans.—Refrigeration by the cold air process is carried out as follows:—A double acting steam driven air compressor raises the air to about 60 lbs. gross pressure and a temperature of about 300°F . On leaving the compressor this hot air passes to a “cooler” consisting of a coil of pipe surrounded by sea water, and in this cooler the temperature is reduced to about 80°F . whilst the pressure is maintained. On leaving the cooler the air passes through a drying chamber in which the moisture it contains is abstracted and it passes on to an “air expansion cylinder” whose object it is to lower the temperature of the air by allowing it to do work, and as the piston and connecting rod, etc., drive on to the same crank shaft as what the steam cylinder does, the air is enabled to return some of the work the steam engine put out. By so doing the temperature of the air may, according to the cut off arranged in the expansion cylinder, fall as low as 8° below zero or even lower, and it is then exhausted at a lb. or so above atmospheric pressure and passes through a “snow box” or dryer and thence by trunks fitted with flap valves away to the bottom of the ship's holds. By absorbing heat here the air gets lighter and rises and passes by a system of return trunks and valves, back to the suction of the compressor and thus the same air is circulated round and round. To charge a cold air machine at first, the suction is opened on to the atmosphere, but afterwards it is

the return air from the holds that is used and this air often passes round the first drying chamber and by its slight warmth assists in expelling the moisture from the compressed and cooled air.

255. Of what material are the air suction and delivery valves of a cold-air machine made? How are the valves kept on their seats?

Ans.—The suction and delivery valves are usually made of bronze or gun metal and held to their seat by means of lightly made steel springs.

256. How many compressors are there to a cold-air machine?

Ans.—The number of compressors per machine varies with the amount of work it is designed for. One double acting compressor is usually fitted to smallest machines and the number increases to three and even four in very large plants.

257. What is the duty of the expansion cylinder of a cold-air machine?

Ans.—Its duty is to take the compressed cooled air as it leaves the first dryer and by arranging a sharp cut off by means of the separate expansion valve fitted to this cylinder the air expands very much in doing work within it and hence its temperature falls to as low as 80° F. below zero and then it is discharged through trunks to the holds. This very low temperature allows the air to absorb some heat from the trunks, etc., as it goes through them and still lets it arrive in the holds sufficiently cold to chill them down as well.

257. ALTERNATIVE SETTING.—How is the air lowered in temperature in a cold-air machine? What kind of valves has the particular part? How is the temperature of the exhaust air regulated?

Ans.—When work is done by an agent it loses heat thereby, so the compressed air is sent to a cylinder wherein it drives a piston and by reason of the main and expansion slide valves being arranged for a very sharp cut off, only a small quantity is allowed to pass in and therefore it expands greatly, falling thereby in pressure and temperature and exhausts very cold. If a later cut off is arranged for, the air temperature is higher and *vice versa*.

258. What objection is there to the presence of moisture in the air passed through the cold-air machine?

Ans.—The presence of moisture in the air forms a kind of sleet or semi-frozen slush to accompany the air to and from the expansion cylinder, wherein it is apt to do serious damage by chokage before it actually leaves this part.

259. How is water to some extent removed from the air? What is the minimum temperature of the air?

Ans.—Cocks are fitted to the air cooler and to the "dryer" just after the cooler; these should be opened about twice every hour and the water blown out. The temperature of the air as it exhausts from the expansion cylinder may be as low as -80° F., but usually a temperature of about -40° to -60° F. suffices here.

260. What is the maximum pressure found in the compressors of cold-air machines?

Ans.—About 60 lbs. gross, per square inch is about the usual maximum, but occasions may arise where this goes up to about 70 lbs.

261. What kind of pressure and other gauges are used in cold-air machines?

Ans.—Two ordinary Bourdon pressure gauges marked in lbs. per square inch are generally fitted, one for the steam supply and one for the air on delivery from the compressor. If the plant be a large one having its own condenser, then a vacuum gauge will be fitted as well. Thermometers should also be fitted to register the air temperature before going to the holds.

262. In refrigerating engines generally, where is the exhaust steam led?

Ans.—If the plant is small the exhaust may pass to the main condenser, and though this answers all right while at sea, yet in port with the main engines stopped the necessity for an independent condenser arises and it is better to always have this and send the freezer engine exhaust to it. With a large plant this latter is fitted and used all the time.

over tanks and under decks as well, and its object is to compel the freezing agent to only absorb heat from the air and cargo *within* the hold and to prevent a constant pouring in of heat from the outer atmosphere.

263. ALTERNATIVE SETTING.—If the evaporator coils of a freezing plant were arranged in an ordinary hold, would the cargo be chilled down as usual? If not, why not?

Ans.—The liquid evaporating in the coils takes in to itself heat (both latent and sensible), and this it gets from whatever surrounds the coils, therefore in an *uninsulated* hold the heat would pour in from ship's sides, decks, etc., instead of merely from the cargo itself and so the temperature of this latter would remain very much higher than desired.

264. Is it prudent to allow the wires of an electric circuit to pass through the insulation? Explain fully.

Ans.—It is most unwise to allow electric light wires to pass through the wooden walls, as there is generally some moisture present about these, and which in time would lead to destruction of the insulation of the cables or wires and thus allow leakage of the current and perhaps sparking to occur with its subsequent risk of fire. If wires must go through insulated holds, let them be covered with lead sheathing and run through steel tubes.

265. Describe the construction of a feed water heater, and give the name of its manufacturer.

Ans.—Note by Author.—The candidate should answer this by describing the construction of the actual one he has been with, but the following is a good description of a Weir's "Injection" heater and shows what is wanted in an answer. (See fig. 99.)

The heater consists of a cast iron chamber having at the top a spring controlled valve, through which the feed enters, being sprayed and falling through small holes in an internal cone it descends as so many fine jets. Surrounding this cone is a perforated cylinder and the annular space formed between this and the heater body is supplied with the heating steam through a non-return valve at side of heater,

thus quickly raising the temperature of the water by yielding up the latent and some of the sensible heat contained in the steam from the exhaust of auxiliary engines as well as some from low pressure casing. This steam condenses and the two lots of water fall to the bottom

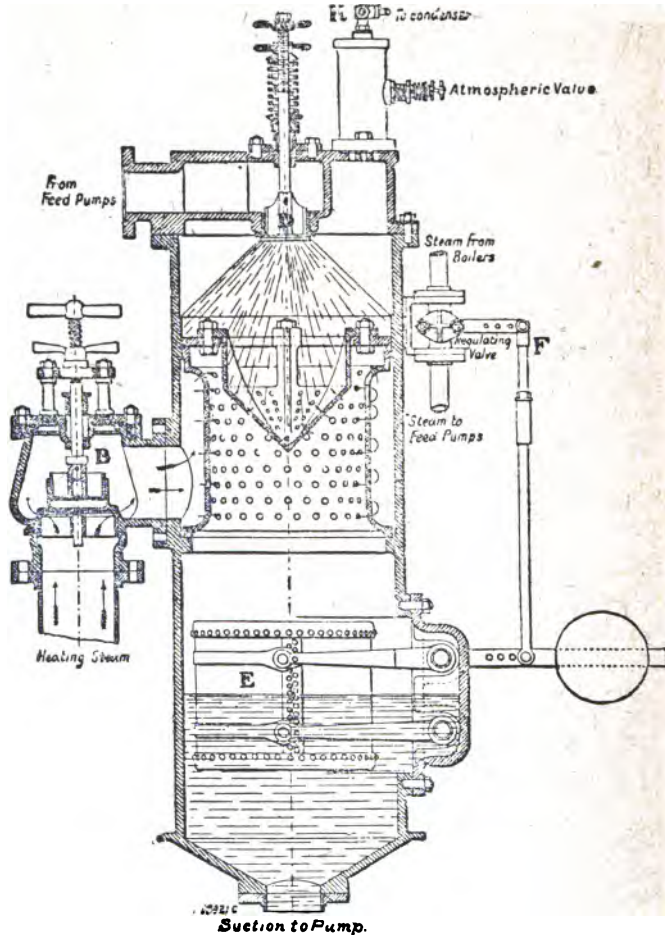


FIG. 99.

of the chamber whence they are removed by the feed pumps, whose speed is controlled by a float actuating the steam valve for these, this resulting in the float rising as the heater fills and so opening more steam to the pumps which in turn work faster and so keep the water down.

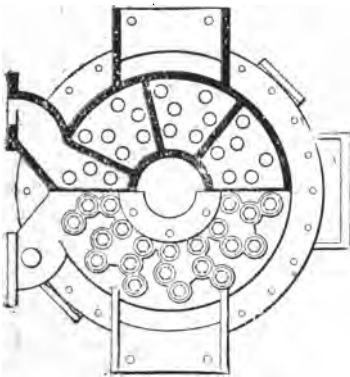
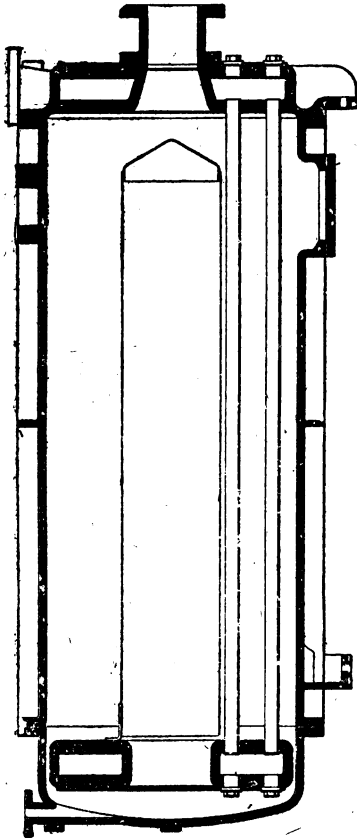


FIG. 100.

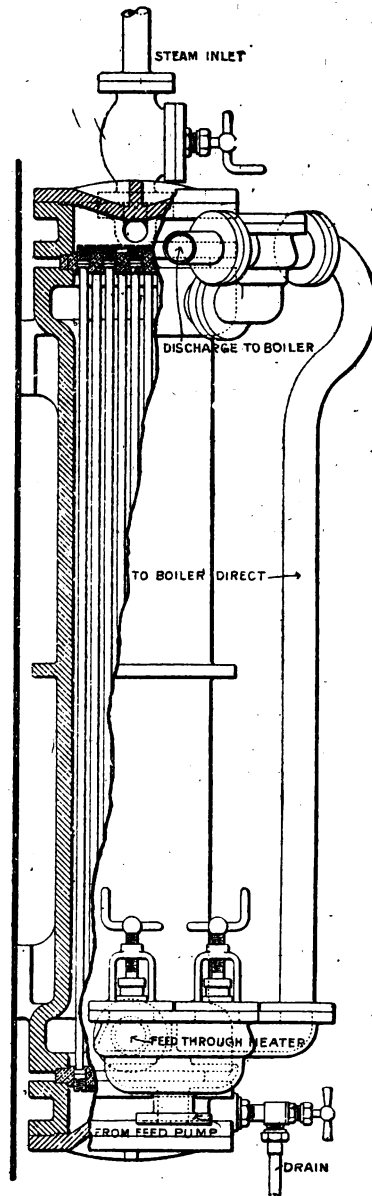


FIG. 100a.

As with this heater the water is freed of air by its being sprayed, a connection is made at the top of chamber, and leading to condenser whereby this air can be drawn away.

Note by Author.—Fig 100 shows one of Weir's "Multiflow" surface heaters used where from lack of head room or other cause the direct contact heater fig. 99 cannot be fitted. The most economical source of steam supply is that of the exhaust from the auxiliaries and it is to be noted that this heater must be placed between the feed pump and the boilers and is therefore subject to boiler pressure. The heating surface consists of copper tubes, 12 W.G., and of such a diameter that enables them to be securely expanded into cast iron heaters or tube plates. The entire element of tubes is free to expand, being held only at the upper end, and if it is necessary to shut off the heater at any time, the feed can be sent direct to boiler by a bye pass valve arranged with the inlet and outlet valves at the cover end.

Plate IX. shows three arrangements of Weir's heaters in connection with single screw, twin screw, and turbine installations and these well repay a study of the positions which have been found the best for ensuring the heated feed being properly taken by the feed pumps.

Fig. 100a shows one of the older type of Weir's surface heaters.

266. To about what temperature is the feed water raised by passing through a feed heater?

Ans.—The temperature should theoretically or ideally be that of the boiler water, but owing to difficulty in obtaining this and pumping it, temperatures of about 200° to 270° F. are more common.

266. ALTERNATIVE SETTING.—What may be said to be the "ideal" temperature for heating the feed to? Why is this not obtained in practice?

Ans.—(To what is given already add.) It costs too much in live steam to obtain this high feed temperature, as in every case there is a species of "mean" point whereat the gain in the boiler by hot feed is at a maximum for the minimum of cost and beyond this the gain is less proportionately to what it is costing.

267. What fittings are usually placed on a feed heater? Why are they necessary?

Ans.—The following are generally found on heaters, viz., inlet and

PLATE IX.





outlet valves for the feed, in case the heater has to be laid off and feed sent through bye pass and valve direct to the boiler. Inlet valve for heating steam, and if heater is one of the "surface" or tube type, then a drain valve or cock for the condensed heating steam to pass to hot well. Relief valve to lift at a predetermined pressure, gauge glass to show height of water in heater, pressure gauge, soda cock and perhaps a scum cock as well.

268. Describe any well-known ash ejector.

Ans.—The best known ash ejector is that of "See's," consisting of a trough supported from the stokehold floor and having a grid at its top and a lid to close down also. It is supplied with water through an "ejector" cock at a pressure of anything from about 150 lbs. to 200 lbs. per square inch pressure and in line with this jet which is directed upwards there passes a pipe of fairly large diameter having a bend of large radius and fixing to a flap valve bolted to the ship's side above the water level.

To discharge the ashes, first open this side valve by means of the rod passing down into stokehold. Start special donkey pump and raise pressure to about 200 lbs. per square inch on its own pressure gauge. See that grid is in place and hopper empty, then open "ejector" cock, when the water will rush away up the pipe and overboard. Now shovel in the ashes, taking care that large pieces of clinker do not pass down, and they will be instantly caught and carried overboard. An air valve is fitted, and it is as well to admit a little air as it softens the working and an escape valve is combined with the ejector cock so as to open and relieve pressure should a choke ensue. (See fig. 104, page 202.)

268. ALTERNATIVE SETTING.—If an ash ejector is not fitted, what takes its place?

Ans.—There is often fitted an apparatus of the hoist pattern, such as Crompton's "atmospheric silent ash hoist," a brief description of which is as follows:—One of the ventilator tubes is used for the ash buckets to travel up and down, and running parallel is the vacuum pipe, which being copper lined has a smooth internal surface, in which works a flexible cup piston to which is secured a steel rope that passes over a swivel head at the top of the tubes, and carries the ash bucket in the ventilator. An ejector is fitted, which when the ship is in port is worked by steam from either the donkey or a main boiler, and by exhausting the

tube of air a vacuum is formed and the atmospheric pressure on top of the piston pushes it down, thereby raising the ash bucket. A slight movement of the ejector handle backwards destroys the vacuum and

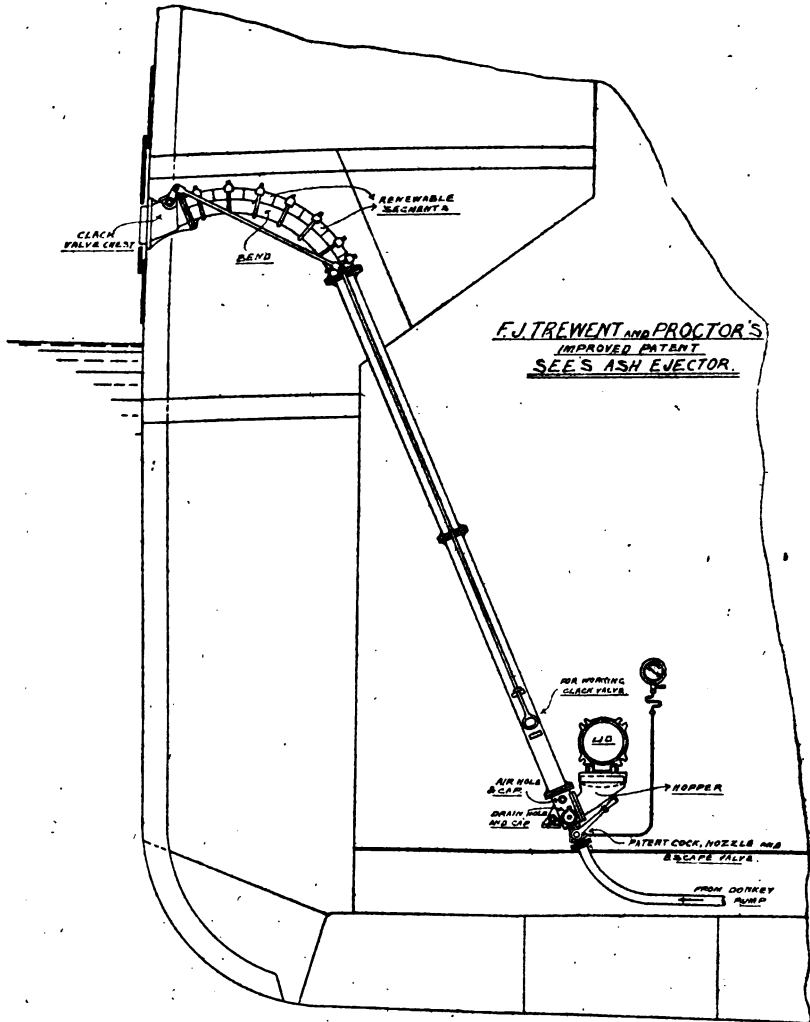


Fig. 104.

the weight of the empty bucket brings this down again to the stokehold. When at sea, the steam for air exhausting is shut off and the handle of the ejector change cock put over so that communication to the main

condenser can be made and thus the vacuum therein is enabled to operate the hoist.

269. Describe any well-known independent feed pumps.

Ans.—Weir's are amongst the best known and most widely used of independent feed pumps. They consist of a steam cylinder mounted vertically above the pump chamber, and of a diameter slightly larger than this latter, so that if the discharge from pump becomes "nipped" the water and steam pressures almost directly balance each other and

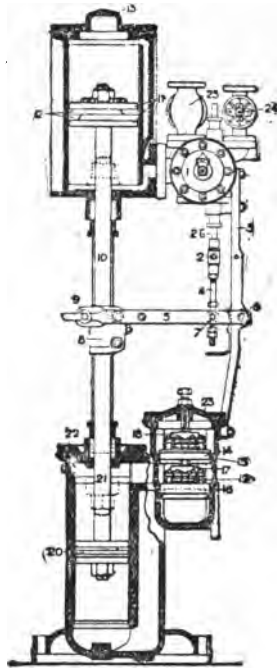


FIG. 105.

there is no breakage as pump stops. Steam is admitted to the cylinder by two valves, one the "main" valve, working horizontally and being circular at the two ends, but having a flattened back upon which works the "auxiliary" valve in a vertical direction. The main valve is moved to and fro by steam admitted between either end, and the "cap" it works in and this steam are controlled by the auxiliary valve, which latter also cuts off the main supply of steam to the pump cylinder. The main valve having passages through it which correspond with the

respective ports, etc., leading to top and bottom of cylinder as well as an exhaust port, and in working, the first action of the auxiliary valve is to admit steam to blow the main valve either to the left or to the right, and so open communication to the bottom or the top of cylinder, and, at the same time, open the *other* passage to the exhaust. The auxiliary valve having a *trifle* before this opened up the steam ready to pass through the main valve and to cylinder as soon as the horizontal movement has taken place. This auxiliary valve is worked by a spindle passing down through a stuffing box and whose lower end is taken by a rod and adjusting screw, which receives vertical motion from an arm fulcrumed on the front stay of the pump, and moving up and down with the crosshead. As the main valve can only rest to the left *or* to the right, one or other passage must always be open for steam to the cylinder, and hence there is no dead centre with these pumps, which are double acting and have the suction and delivery valves in groups, 8 suction and 7 delivery, which thus sharpens up the discharge and makes it more regular.

(*Note by Author.*—Greater details as to the valves of Weir's pumps will be found in *Brown's Slide Valve for Engineers.*)

**270. Are independent feed pumps automatic in their action?
Explain the action.**

Ans.—As a rule independent feed pumps are automatic in action, this being effected by a float fitted either in the heater, feed tank, or drum of a water-tube boiler. The float is connected with the steam valve of the pumps, and as the water accumulates in heater or feed tank the float rises and so opens more steam on to pumps which work faster and so remove the water, but with the float in the boiler a rise of water level is made to shut down the steam valve a little, and hence *less* feed is sent into the boiler. As the level falls, the valve opens and the pumps set away faster, thus feeding up the boiler.

**271. What advantage, if any, have independent feed pumps
over feed pumps worked by the main engines?**

Ans.—The advantages are several, amongst which must be mentioned ability to deal with hotter feed due to the speed of pump being slow, facility for overhauling without stopping main engines, less air sent in with feed water, due to the pump being able to be kept in a better condition than the average engine-driven pump, and it is claimed that less power is taken to operate them, but as to this it is not always the case.

271. ALTERNATIVE SETTING.—If you desired to use a feed pump that allowed less air to pass into boiler what type would you select? Why?

Ans.—(That already given will do.)

272. Describe the construction of a feed filter, enumerating its valves and cocks.

Ans.—Whilst the actual construction varies with the individual maker, still the principles remain the same always and consist of having a cast iron chamber containing the filtering material of either coir, towelling, or cloths through which the feed is forced and any dirt or grease left behind on the filtering material. The chamber is fitted with inlet and outlet valves, and bye-pass pipe with valve, and also carries pressure gauge, drain cock, steam and soda cocks, for use when cleaning filter, and an air cock.

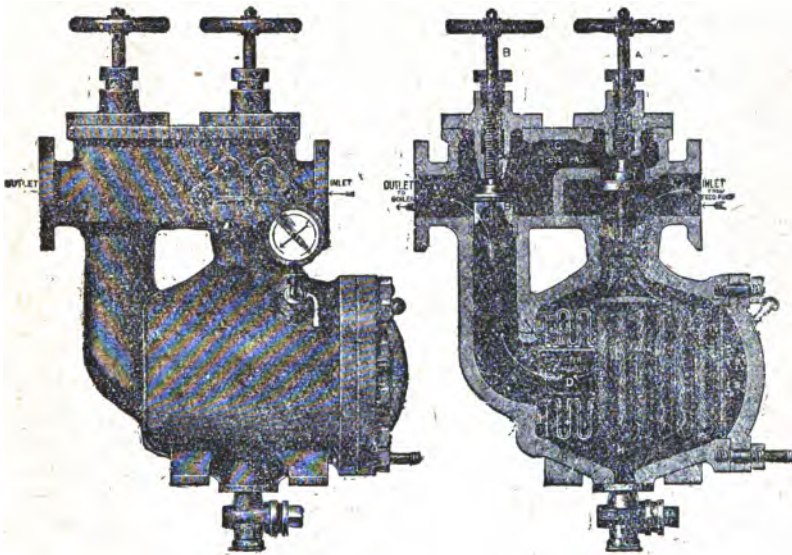


FIG. 106.

Messrs. Railton, Campbell & Crawford's filter consists of a cast iron chamber carrying inlet and outlet valves, also the filtering material. A bye-pass, cock for draining, and a removable door, and to operate this filter proceed thus. To start, first open outlet *B* and then open inlet *A*,

thus allowing the feed water to pass through filtering chamber *D* and outlet valve *B*, and so on to the boilers. When blowing the filter through, shut down valve *A* on bottom seating first, and then shut *B*. Open drain *E*, and then open *A* a little, this washes outer part of filtering chamber *D*. Shut *A* and open *B*, thus cleaning the inner part of chamber *D*. When changing filtering chamber *D*, shut down *A*, and then *B*, open drain *E* and take off door *F*, draw out the filtering chamber *D*, and replace by the spare one. Then put on the door *F*, shut drain cock *E*, and start as above.

273. How can the filter be cleaned? What ingredients are generally removed when cleaning takes place?

Ans.—Before starting to clean a filter the feed must be sent *via* the bye-pass pipe to the boiler, so first open this valve and then close the inlet and outlet valves on the filter itself. If a thorough cleansing is desired, take off the door and remove filtering material and either substitute new or else boil well with soda the old cloths, etc., and when clean replace in position. Tighten down the door again and open up inlet and outlet valves, *after which* the bye-pass may be shut. If, however, we do not wish to remove the filtering medium, then proceed as before with the valves, but, now put a strong solution of soda in through the soda cock, and by means of the steam cock boil the whole lot for a time, after which open the drain cock and allow the sludge which has collected at the bottom to be blown out.

The ingredients usually found consist of oil, grease, mud, etc.

273. ALTERNATIVE SETTING.—How can you tell when the filter needs cleaning? Is the normal pressure shown on their gauge the same as the boiler pressure? If you saw the pressure suddenly drop, what would you know had happened?

Ans.—The pressure in the filter, even when quite clean, is always some lbs. higher than the boiler pressure, due to resistance of the towelling, coir fibre, etc., but when we observe it to get, say, 30% or 50% more, it is high time the filter was laid off for cleaning, as the excess pressure tells us the water has great difficulty in passing through the dirty cloths, etc. If filter be not cleaned, the escape valve on pump chamber will blow and feed water be lost.

If the pressure suddenly drops it indicates that the dirty cloths

have ruptured owing to their inability to withstand the excessive pressure, and the filter, in consequence, is quite useless until new cloths have been inserted.

**274. What is the intercepting material in a filter made of?
How is it fitted?**

Ans.—The filtering material may be either coir (cocoanut fibre) coarse and fine towelling, flannel, or other woollen substance, and sometimes a species of felt. The ways of fitting the filtering material are many, but all depend upon the placing of the cloths, etc., over perforated brass plates or cylinders and to prevent it being burst into the holes, there should be a thin sheet of wire gauze placed between, to act as a support for the towelling, etc., as the pressure being external the tendency is to force the material into the holes of the plates or cylinders. After placing in position, the substance is held so by either bolts jamming together the series of plates and cloths, all tight, or in the case of the cylinder form, by lashing the filtering substance with marline or copper wire.

275. Describe an evaporator, and mention the type.

Ans.—An evaporator consists of a cast iron chamber formed either in one piece, or of an upper and lower chamber bolted together. In either type the lower portion contains a series of coils of heavy, solid-drawn, copper tubes, one end of each coil connecting by a conical coupling to a live steam supply chamber, while the other or outlet end of the same coil is connected to the drain or outlet chamber, these being cast upon the side of the evaporator body. The space surrounding these coils is filled with sea water taken by a special small pump from the circulating discharge, and at a temperature of about 100-120° F., and by the condensation of the steam in the evaporator coils, some of this sea water is driven off as *fresh* vapour, passing baffle plates to prevent priming, on its way to the upper part of the evaporator, from which it may pass either to the lower pressure casing, or else to the condenser and so supply fresh water to make up feed. Whilst this description is particularly of the Weir's evaporator, the principles remain the same with any make of machine, being in effect the same as what occur in a boiler, only using a different agent for the heat supply.

Note by Author.—The figs. 107 and 108 show two of Messrs. Weir's evaporators, the former the usual pattern for outputs up to about 20 tons per day, and the other the "Lunette" type for larger outputs.

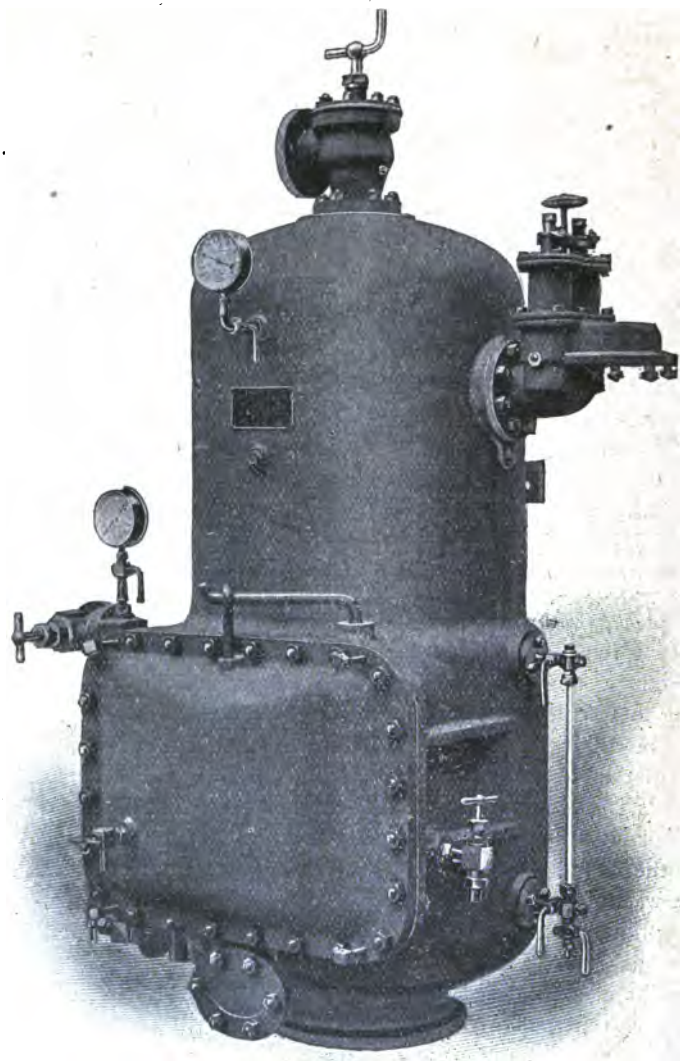


FIG. 107.

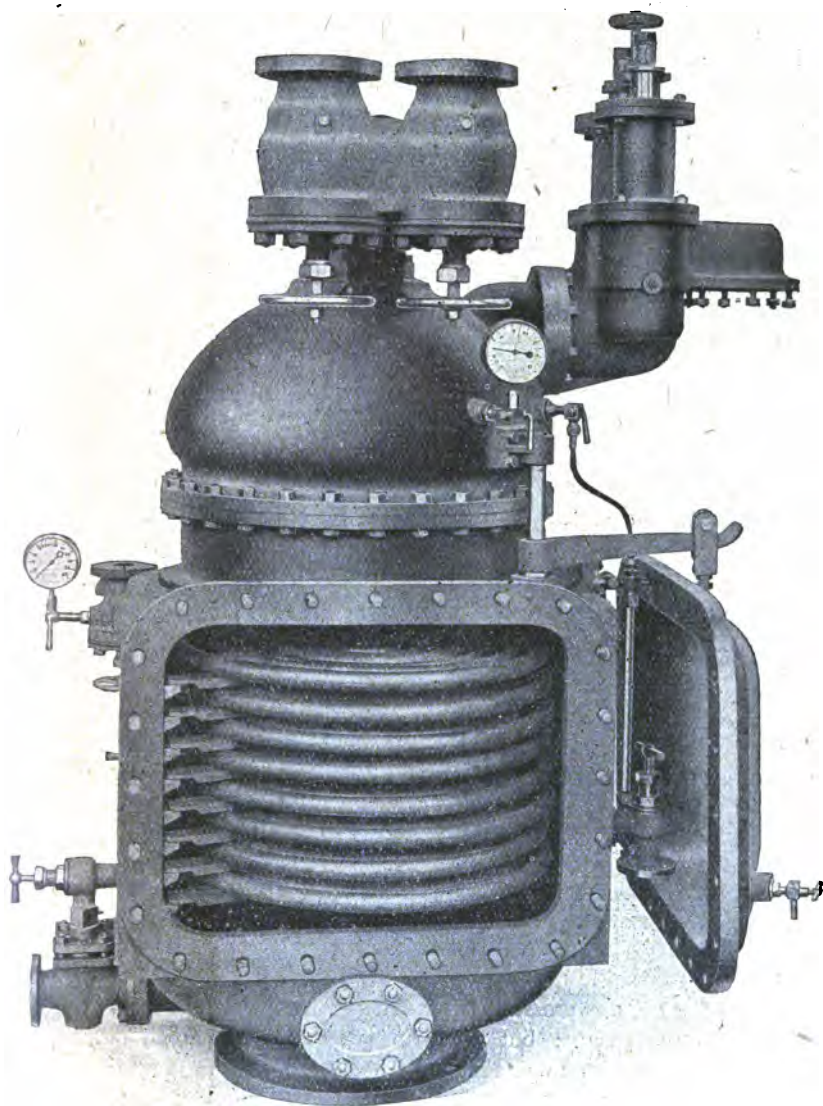


FIG. 108.

Plate X. gives sectional views of the first type, and appended is a reference list of the names of the various parts.

- | | |
|--|---|
| 1. Shell. | 17. Salinometer valve. |
| 2. Main door for withdrawing tube coils (6). | 18. Cock for blowing off to sea. |
| 3. Hand cleaning door. | 19. Top cock for water gauge. |
| 4. Baffle plate or deflector. | 20. Bottom cock for water gauge. |
| 5. Supports for coils (6). | 21. Safety valve. |
| 6. Evaporating tube coils. | 22. Outlet valve for the generated steam. |
| 7. Inlet steam coupling for coils. | 23. Compound gauge for generated steam in shell. |
| 8. Drain outlet coupling for coils. | 24. Cock for compound gauge. |
| 9. Coupling nuts. | 25. Pressure gauge for inlet steam to coils. |
| 10. Inlet steam heater. | 26. Cock for pressure gauge (25). |
| 11. Drain header. | 27. Swing crane bar for door. |
| 12. Drain collecting pocket. | 28. Eye bolt for supporting door on crane bar. |
| 13. Inlet valve for steam coils. | 29. Connection from top of water gauge to steam space of shell. |
| 14. Valve for drain from coils to hotwell. | |
| 15. Feed check valve. | |
| 16. Brine valve. | |

Plate XI. gives sectional views of the "Lunette" type and the references are the same as the above with the addition of 1a, dome of evaporator.

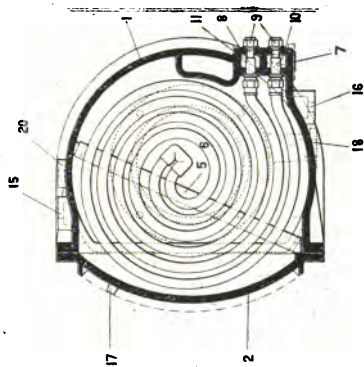
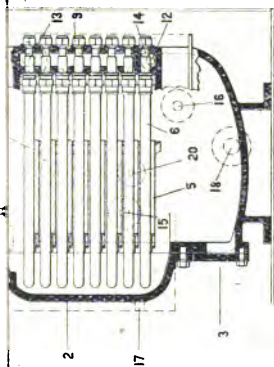
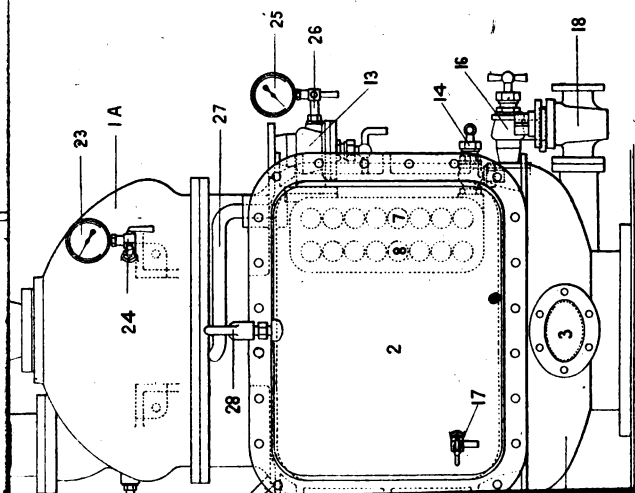
276. What fittings are necessary with evaporators?

Ans.—The usual mountings consist of steam inlet valve, vapour outlet valve, feed check, brine valve, drain valve and coupling to hot well, blow-off cock, safety valve, water gauge, pressure gauge, compound gauge, salinometer valve or cock, and we may include a gun-metal feed pump, to work off the main engine lever.

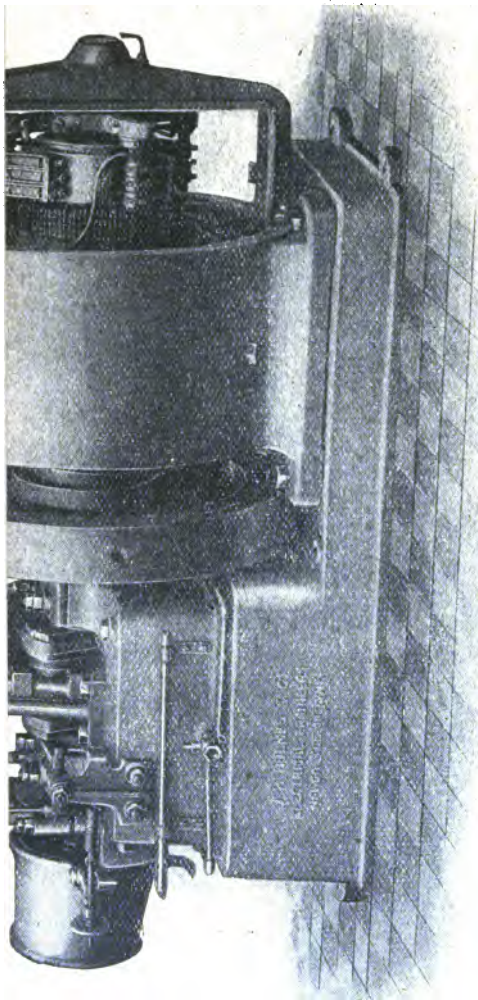
277. How is the brine got rid of in an evaporator?

Ans.—If the evaporator works under a pressure, *i.e.*, the generated steam passes to the low pressure casing, it is often worked on a continuous blow off, the pressure carried being a few lbs. (say 2 or 3) above that in the casing; but when an evaporator is worked on a vacuum (vapour passing to condenser), then to blow out the brine, shut vapour valve and drain from coils, and allow the pressure to rise to say about 8 to 12 lbs. per square inch. Open blow off cock and keep it blowing until sufficient brine has been removed to reduce the density below $\frac{8}{32}$. When finished blowing, close blow off cock and

PLATES X. AND XI.



To face page 210.



To face page 211.

open up the vapour valve and drain. Sometimes all the valves are closed after the pressure has been allowed to rise and the evaporator blown right out through the blow off.

277. ALTERNATIVE SETTING.—If the evaporator primes what is the density of the priming liquor? Is this the actual density of the feed to the boilers in such a case?

Ans.—Whatever density the evaporator is being worked at, $\frac{2}{32}$ to $\frac{3}{32}$ is the density of the priming liquor, but seeing that this is carried along with the fresh steam (or vapour) which has been supplied by the evaporator and the two lots finding their way to the hot well, results in the fresh water only increasing its density slightly, still priming must not occur at all.

278. How may the evaporator coils be cleaned?

Ans.—The best plan is to remove the door on the evaporator, and, by means of a piece of hard wood or a blunt chisel, tap the tubes and break off the scale, taking care not to damage the copper pipes.

Another plan sometimes successful is to empty the evaporator of all water and then open up steam on to the coils, so thoroughly heating these. Next shut off the steam and open up the water, when by the contraction of the tubes it is expected the scale will be cracked off. Generally this method is far from efficient.

279. What is a dynamo? Describe its various parts. For what is it used?

Ans.—A dynamo is a machine in which mechanical energy is converted into electricity by the means of rotating bundles of insulated copper wire rapidly in a strong magnetic "field."

Its principal parts consist of a series of electro magnets of north and south polarity alternately, mounted on a ring, yoke, or carcase, and in number either 2, 4, or 6 for average marine dynamos. In the field produced by these magnets all pointing to the centre of the ring or yoke there rotates the "armature" of thin iron or steel insulated slotted discs and containing a certain number of bundles of insulated copper wire arranged in slots running parallel to the shaft and all the way round the periphery. The shaft of this armature carries the commutator, consisting of taper section drop forged copper bars,

thoroughly insulated from each other and the shaft, and held firmly in position by clamping rings. To the bars are attached the ends of the separate bundles of armature wires, and upon the surface of this commutator, whose function is to convert the alternating current in the armature wires to a continuous one for the outer circuit, press the brushes which collect the electricity. These in number are usually the same as the number of poles, and are supported by, but

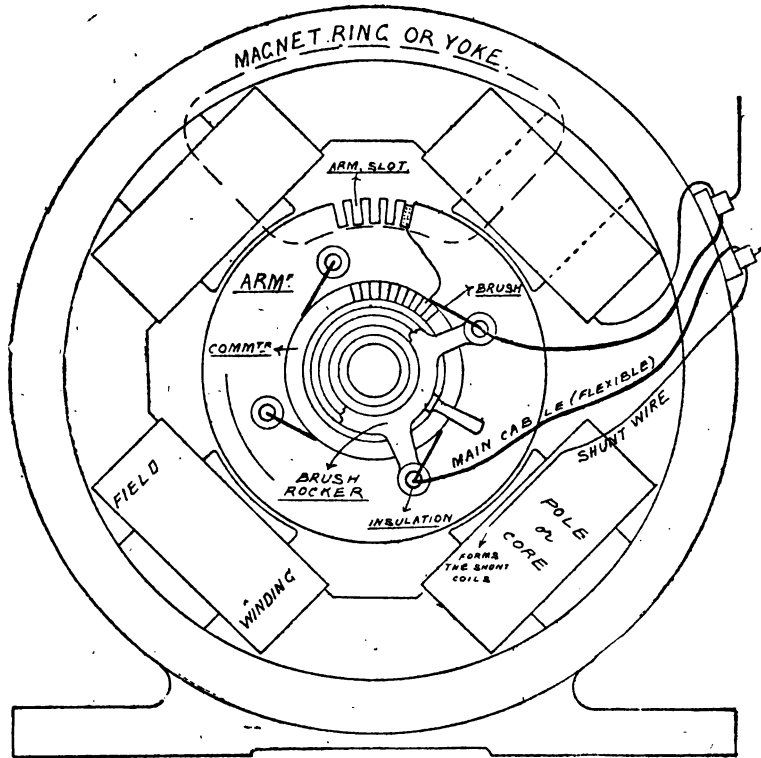


FIG. 109

insulated from, what is called a brush rocker, mounted upon the same bearing that carries the commutator end of the shaft. From the brushes pass flexible leads, and all coming from the portions of the commutator under the influence of the south poles are gathered into one large sized flexible cable, and all the others coming from the

brushes under north pole influence are gathered to another equal sized cable, and thus the customary two main leads of a dynamo are obtained, the north forming the + and the south the - poles, the former being the outgoing and the latter the return path.

When the main cables have led the current to and from the terminals of the machine, branch wires are taken and wound round the field magnet cores in order to produce the powerful degree of magnetisation. This is done in one of three styles. A fine wire wound a

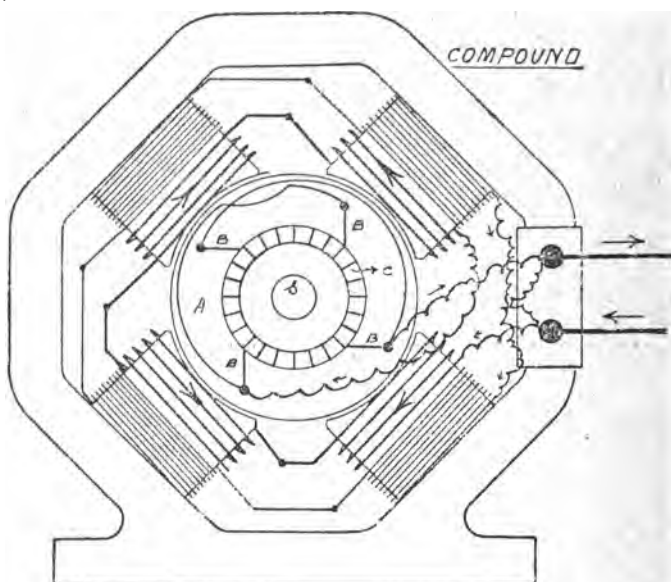


FIG. 112.

great number of times on each core and carrying only a trifle of the whole current, and forming the "shunt" style; or the whole of the current supplied by the dynamo may go round the field magnets by a large diameter copper wire, and in comparison a very few turns are now needed, being known as the "series" method; or yet a third style, called "compound," which uses both the foregoing, the fields having a few turns of series as well as a large number of coils of shunt winding.

The uses of a dynamo are to supply electricity for such purposes as lighting, heating and driving motors.

280. In what respect does an electric motor differ from a dynamo? Where are electric motors sometimes used on board ship?

Ans.—So far as construction goes there is no difference between a dynamo or a motor. In the former, we must supply mechanical energy and so produce electricity, whereas in a motor we must supply it with current and it will then give out mechanical energy for the driving of fans, cranes, hoists, etc.

280. ALTERNATIVE SETTING.—If an electric current be sent to a dynamo will it act like a motor does? If so, does anything about it require radical alteration?

Ans.—Any well designed dynamo will run as a motor, if supplied with current, provided that before starting we move the brushes backward from the vertical through commutator, instead of their normal forward lead. There is no radical alteration required.

281. Describe a system of electric lighting employed on board ship.

Ans.—The principal parts employed in any system of ship lighting consist of a continuous current dynamo direct coupled to a steam or

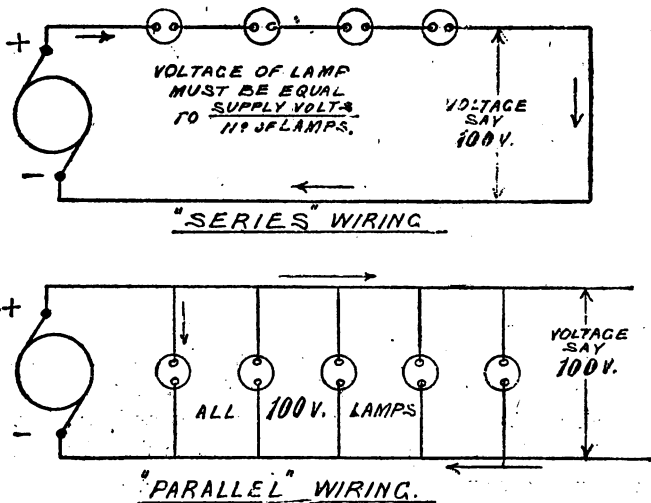


FIG. 113.

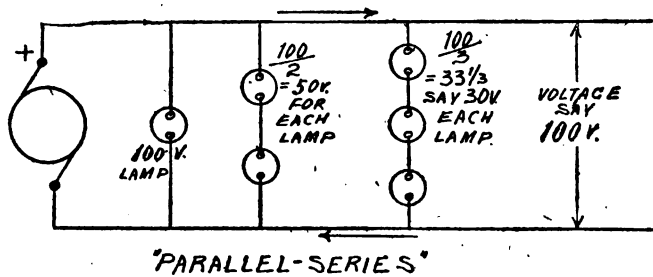


FIG. 114.

oil engine, and generating current which is led to and from bus bars placed upon a main switchboard. Connection is made to the + bar by means of fuses and switches, thus tapping off current which is led by smaller cables away through the ship to wherever it is required. Those necessary for lighting usually have a smaller switch, or fuse, board to which the above cable acts as a supply and from which still smaller leads go to the individual lamp or group of lamps. By this

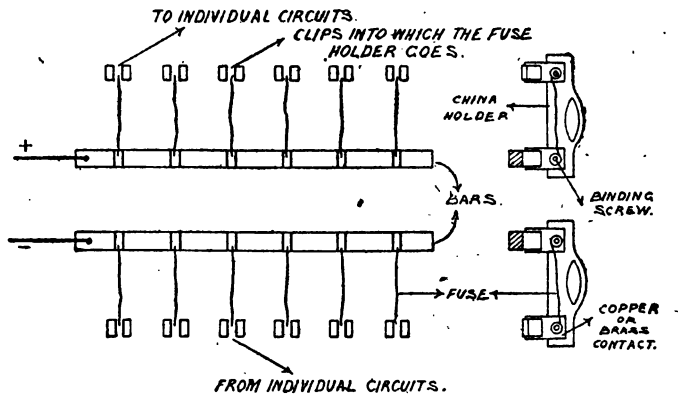
ARRANGEMENT OF A DISTRIBUTION OR FUSE BOARD.

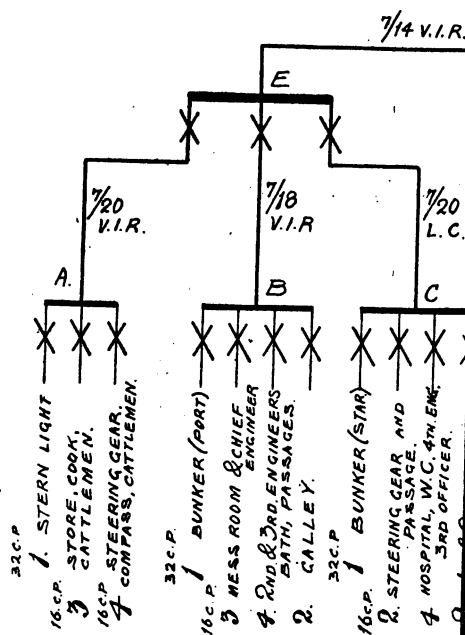
FIG. 115.

means the various lighting circuits can be switched on and off as required without interfering with the others. From the lamps, motors, etc., return wires are taken which finally go back to the - bar on the main board, passing possibly on their way fuses and switches. The board is fitted with a voltmeter and ammeters to record the pressure and quantity of current respectively.

The lamps, etc., may be arranged either on the "single wire hull

PLATE XIII.

- A. 1-3 WAY 5AMP. FUSE BOX, with 2 switches
Cattlemen's room. (Star. af
- B. 1-4 WAY 5AMP. FUSE BOX, in Chief engine
room (Port side) S. POLE.
- C. do. in 2nd Officers
- D. 1-6 WAY do. with 5 switches in
main switchboard. S. P.
- E. 1-3 WAY, 10 AMP. do. in 2nd Officers
- F. do. do. in Pantry
(saloon) D. POLE.
- G. 1-6 WAY, 5 AMP. do. with 5 switches
in chart room. D. P.



To face page 217.

return" or "two-wire" systems. The former is the older and less satisfactory method, having only an advantage in using less cable. The returns from lamps, etc., are attached to the skin of the ship, or deck beams, or frames and then to one of these near the dynamo there is fixed a short piece of large cable, thus bringing the current back to the

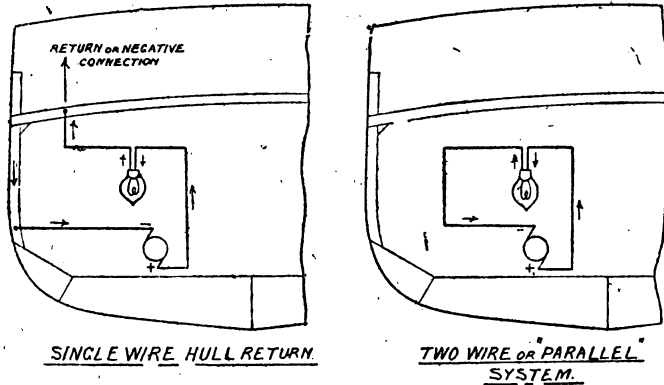


FIG. 116.

generator. This method affects the compass badly and so within a radius of about 30 feet of this part, all wiring must be on the two-wire system, which consists of + and - cables run more or less parallel to each other throughout the ship and the lamps, etc., are supplied as usual from the +, whilst the returns are connected to the - wire. With this method there is twice the insulation between + and - there is with the former, hence leakage troubles are much reduced.

[Plate XIII. shows a wiring plan as carried out by Messrs. Holmes & Co., and is typical of ship installations.]

282. How is the position of a fault in the electric circuit discovered?

Ans.—Faults divide into two main divisions, breakage of cables, or short circuiting. Provide yourself with either a lamp in a holder fitted with two pieces of wire, or else a galvanometer, and assuming the former, start the dynamo and if the ammeter does not show excessive current passing there is no short circuit, so on the wires where no light or power is being obtained scrape away the insulation on each a few inches from one another and touch each lead with one of the lamp wires; if lamp glows, the circuit is complete up to this point and we

must try again nearer to where the motor, etc., does not work. When the place is found where a trial with hand lamp shows no glow, between there and the previous spot exists the break, and working back will locate it. (See fig. 118.)

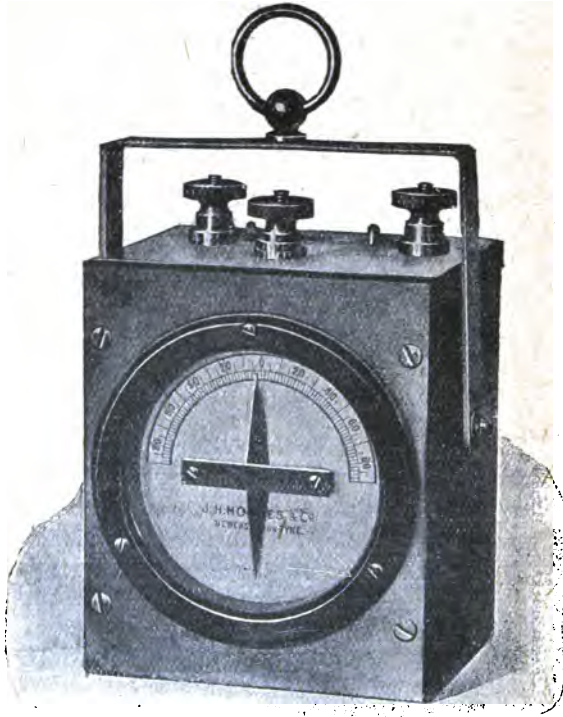


FIG. 117.

To test for a short circuit obtain a galvanometer of a fair resistance, run the dynamo below its usual voltage, disconnect one of the main cables from the machine and insert here the galvanometer. Close main switches but *open all* the others and then if there be a "short" on the suspected circuit, the galvanometer needle will deflect owing to current passing *via* the short, as otherwise there should be none passing.

282. **ALTERNATIVE SETTING.**—What is meant by a “fault” on a circuit? How can such be brought about? Is the single wire hull return or the two-wire system more liable to faults?

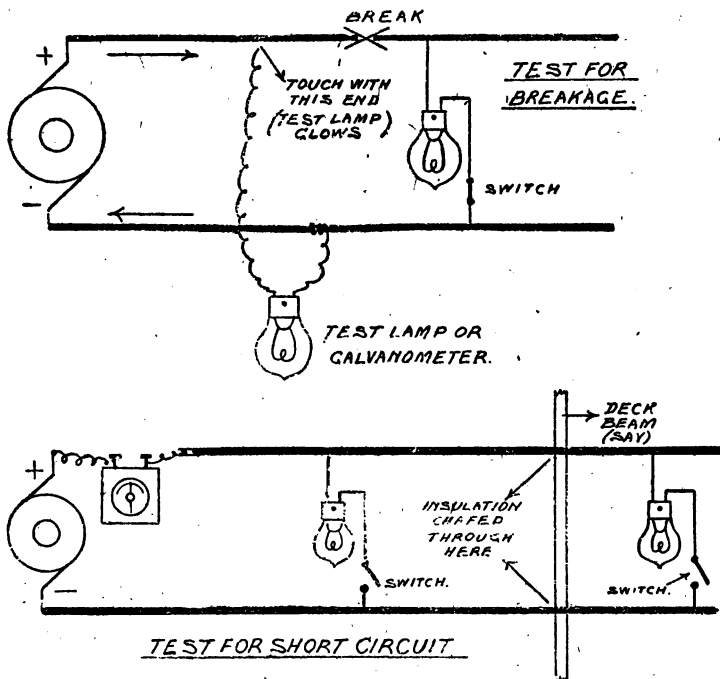


FIG. 118.

Ans.—A fault may be either a break, an “earth” or a short circuit, and if the latter, generally caused by the insulation chafing through and the wire thus bared coming into contact with a part carrying the other portion of the current. If wires pass through holes that are not bushed with hard wood, vulcanite, fibre, porcelain or the like, the vibrations soon have the coverings worn through and bare copper touches the ship, which if of the single wire system means a dead short on that circuit at once. The two-wire system is better as to produce a “short” here, both cables must become bared. An “earth” is produced when either the + or - wire comes into contact with the ship (two-wire system). It is really a bad leakage of current.

283. What is "sparking," and may it under some circumstances (naming them) be a danger?

Ans.—Sparking is the light visible when any part of a circuit carrying current is *broken*, as thus a small arc is set up which is both luminous and destructive. It roughens the surfaces between which it occurs, and if gas be present is quite sufficient to ignite it and cause serious results. When taking place on the commutator between the brushes and the surface of this part, the latter soon gets considerably burnt and roughened leading to still increased sparking until in the end a falling off in the output is observed. It may be caused by slack brushes, overload on machine and brushes in wrong position round the commutator or loose connection at armature. It also occurs at every switch on opening, hence these should break the circuit as rapidly as possible so that the arc does not get time to become so large or do so much burning.

283. ALTERNATIVE SETTING.—When a circuit carrying current is broken a light is seen, what is this? Where does it often occur?

Ans.—(That already given will do.)

284. What is "short circuiting," and to what evil may it give rise?

Ans.—Whenever an electric current leaves the path designed for it and takes a quicker road back to the dynamo it is said to be "short circuited." Thus if the + and - wires have their insulation chafed through and touch each other the current goes out by the + wire but returns by the metallic contact with the - and so everything beyond this point receives practically no current at all. As the resistance of a "short" is very low, it results in a considerable load coming on the dynamo and fuses must be proportioned so as to blow when such a short occurs. If this does not happen the armature itself may become burnt out

284. ALTERNATIVE SETTING.—If lights go out upon a circuit and yet the ammeter records more current, what has happened? If the usual fuses blow as soon as they are replaced what does it tell you?

Ans.—(That already given will do.)

285. What means are employed to prevent any part of the circuit becoming overheated?

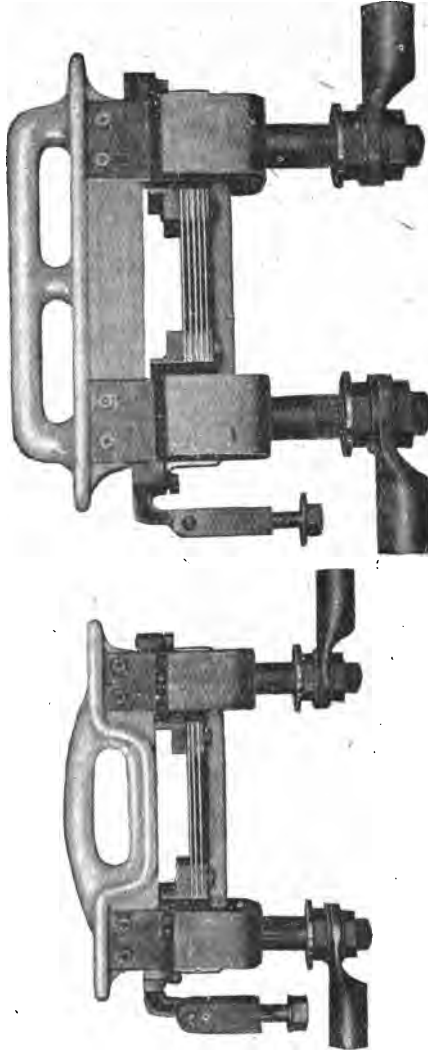


FIG. 119.

Ans.—What are called “fuses” are inserted at certain places upon the leads. These consist of pieces of tin wire or strip attached to brass terminals or binding screws mounted upon porcelain and to these

screws are led the ends of the + or - cable. Thus the wire goes from the switchboard to one holder and on from the other to the lamp and the gap so formed is bridged with the easily fused metal tin (or a tin-lead alloy). When an excess of amperes pass it causes undue heating of this part of the circuit and reaches its melting temperature long before the copper wire does, hence it "blows," as it is called, and by rupturing breaks the flow of current and protects the circuit, lamps, etc. (See fig. 119.)

On main switchboards larger forms of fuses are met with, or in their place are found automatic switches which come open when the current passing them exceeds a predetermined amount.

286. Describe the features of an arc lamp.

Ans.—Whilst the details of arc lamps vary with the different makers, the principles remain the same. They consist essentially of an upper or + carbon rod of a diameter rather larger than a lower or - carbon. These rods are in contact with each other when current is off, but immediately on switching this on the mechanism in the upper part of the lamp moves the carbons apart for about $\frac{3}{16}$ " and the current then jumps from the + to - rod. By so doing the arc forms and light is given out, being assisted by the raising of the carbon tips to incandescence and the driving off of a great number of minute particles of carbon dust, also incandescent. Next as the rods wear away the mechanism is arranged to feed them together so as to maintain the original distance, and finally when current is switched off, it allows the carbons to come into contact ready for the next time of lighting up. The mechanism is usually operated by an electric current shunted off the main wire so that these lamps are quite automatic in action. A globe surrounds the carbons and a casing goes around the mechanism above. The light given is extremely brilliant and much more economical than a carbon filament glow lamp.

287. Describe the construction of a glow lamp.

Ans.—The ordinary glow lamp consists of a glass bulb very thoroughly exhausted of air in order to prevent combustion of the filament. At the upper portion or neck of the bulb there is fused in, before exhausting, a piece of glass carrying two platinum wires whose lower ends are united by carbon cement to the ends of the filament, this latter being either a carbon thread, or the much more economical

one of tantalum, or tungsten metal. The upper ends of the platinum wires are soldered to short lengths of common wire, which do not go through the glass, and lead up to, and are soldered on to two small brass plates fixed on the top of the cap of the lamp, this being done after the cap has been attached to the bulb by paris plaster. These plates form the means of leading in and out the current from the pressals in the lamp holder, and by reason of the resistance the filament offers to passage of current it becomes incandescent and therefore luminous.

288. What is the usual candle power of the small glow lamps in general use on board ship?

Ans.—The candle power varies according to whereabouts the light is required, but the usual intensities are 8, 16, and 32 candle power. If more than this is needed, a cluster of from two upwards is used.

289. Define the following terms:—Ampere, volt, ohm, watt. What is the measure of an electrical horse power?

Ans.—By ampere we understand the unit denoting "quantity" of current as so many amperes. The current sent through 1 ohm resistance by 1 volt electro motive force is 1 ampere. Volt is the unit of pressure as commonly spoken, but more exactly is the unit of intensity of an electric current, and may without appreciable error be considered in every-day language as the equal of electro motive force. Ohm is the unit of resistance to flow of current. Watt is the product of 1 volt by 1 ampere, or watts = volts $\times$ amperes, and 746 of these watts = 1 electrical horse power.

290. Explain the uses of switches, brushes, commutators, cut-outs, field magnets, armatures, and resistance coils.

Ans.—A switch consists of a moveable piece of copper capable of being brought in contact with a fixed piece to which one end of a cable or wire is led. To either the moving piece or a fixed part similar to the other is attached the end of the lead or wire going to, say, the lamp, and by means of an insulated handle the moving piece is brought to, or away from, the fixed pieces. It thus closes or opens the circuit and this is its object. The whole should be mounted on an insulating base. (See fig. 120.)

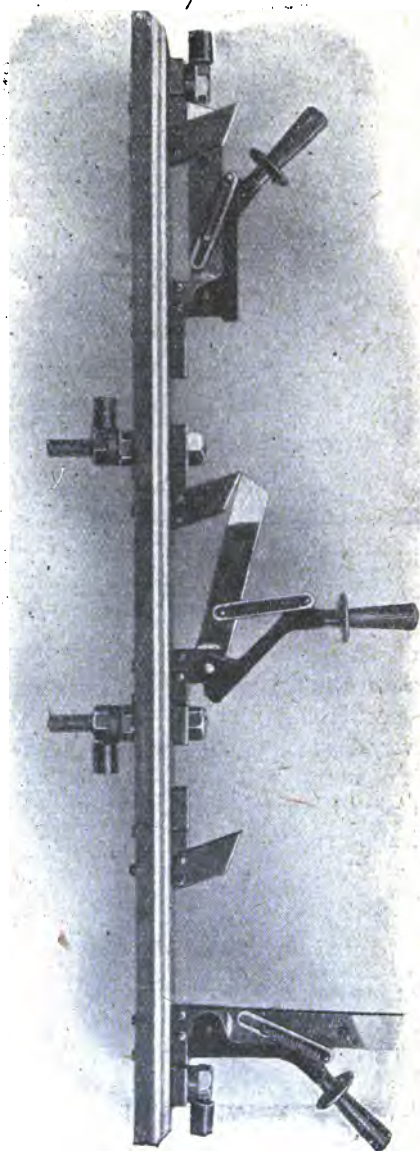


FIG. 120.

Brushes are of copper gauze pressed into rectangular form, bundles of brass wire, or carbon blocks or plates, held in "holders" mounted on, but insulated from, the brush rocker, and they collect the current from the commutator, and by having heavy flexible cables attached to the spindles of the holders the current is led to the main terminals of the machine.

Commutator converts the alternating current in the armature wires into a continuous (or flowing in one direction) current for the outer circuits.

Cut-outs are only fuses, and consist of pieces of tin or tin-lead wire or strip mounted in between smallish terminals or binding screws on a china base, and to which screws the lead is attached. Thus the fuse forms an easily-melted portion of the circuit, and if an excess of amperes pass, the heat due to these soon causes the fuse to melt, when it is said to "cut-out" the lamps, motor, etc., upon that particular circuit. What are called automatic cut-outs are magnetically controlled switches which open under an excess load.

Field magnets are the powerful electro magnets necessary for the maintenance of the magnetic field for the armature wires to cut through and so cause current to be generated. They are of cast iron or cast steel and insulated, and then wound with insulated copper wire, either fine as in "shunt," thick as in "series," or with some of both as in "compound" winding.

Armature is the congregation of thin stampings insulated from each other, fixed upon the shaft, and carrying the insulated armature wires in a direction parallel to the shaft. These therefore cut through the magnetic lines of the "field" and current is generated of an alternating nature.

Resistance coils consist of coils of some metallic wire having a much greater resistance than copper, such as platinoid, eureka, German silver, etc., and on the passage of current they heat up, thus serving as one means of electric heating. When the quantity of current has to be reduced in any one circuit we can only do it by making the total resistance therein greater, to do which we connect one end of the supply wire to the beginning of the set of resistance coils and to the movable contact arm, which travels over a series of insulated studs to which the coils are connected, the end of the wire going on to the lamps, etc. Then when the arm is on the last stud the current has to travel *all* the coils and the resistance is a maximum, resulting in the given voltage causing a much diminished flow of electricity. As the arm is brought round, stud by stud, so the

coils are gradually removed from the circuit, the resistance gets less until on the first stud of all the current goes straight to the arm and

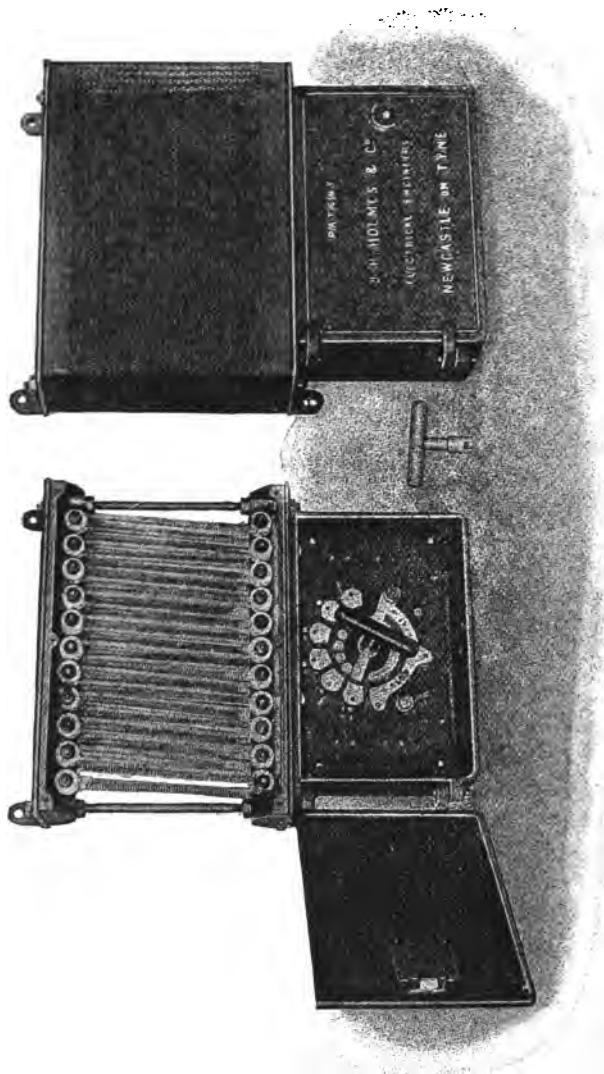


Fig. 121.

away, not experiencing any *additional* resistance. It is then of a maximum value. (See fig. 121.)

291. Why is it desirable to fit a dynamo in a cool place on board ship?

Ans.—As there is always heat produced in a dynamo by reason of it offering resistance to the passage of the generated current and such heat is a loss of work, it follows that to put a machine in an already heated location would be folly, therefore a dry and cool spot must be chosen. Dry to prevent damp setting on the coils when machine is not running and so tending to lower the insulation resistance and cool to prevent any overheating which might burn the insulation, cause electrical leakage and perhaps swelling of the armature windings until they touched the pole pieces of the field magnets.

291. ALTERNATIVE SETTING.—If currents of heated air were allowed round a dynamo what would result? If moisture is present what is the result?

Ans.—(That already given will do.)

292. What undesirable effect will ultimately occur to an electrical wire whose sectional area is constantly diminishing, say through corrosion?

Ans.—With electricity it is the same as with other agents like steam and water, the smaller the area for conveying, the higher the resistance offered, but with electrical wires there is the added risk that, due to reduced area, the resistance becomes sufficiently great to cause enough heat that fuses the wire at this spot.

292. ALTERNATIVE SETTING.—Why should a diminished cross section of wire cause local heating? Is this smaller section used in any part, definitely and usefully? If so, where?

Ans.—To carry current safely in stationary wires calls for an allowance of about 1000 amperes per square inch of section. This will not cause any undue heating, but if a spot about the cable should get reduced to, say, $\frac{1}{4}$ square inch section; then the 1000 amperes *crowding* through this small space give rise to a great deal more heat by reason that *relatively* a greater resistance is felt to the current flow. Fuse strips are often made with notches in the sides about the centre and should the current exceed the normal, by more than a few per cent, this reduced spot rapidly heats up and melts.

293. What danger might arise from leading electric wires through coal bunkers?

Ans.—If by any cause such as insulation becoming chafed through, the + and - wires came into contact so as to cause sparks to form as they came apart, these sparks would ignite the coal gas in the bunkers and so cause a fire, and if the mixture of air to gas was, say, about 6 : 1 there would be an explosion with, of course, increased damage.

293. ALTERNATIVE SETTING.—Fires have been caused on steamers fitted with electric light without any apparent cause at the time. What was the reason?

Ans.—(That already given will do.)

294. Is it better to lead electric wires above or below side scuttles? Why?

Ans.—Any electric wires must be placed in dry spots and as much as possible away from the risk of mechanical injury, therefore run them above the side scuttles and this is often done by placing them in a steel tube situated just under the rail of the bulwark. In other cases they are placed in casings run up solid with bitumen.

295. What instruments are used on board ship to ascertain the strength of an electric current?

Ans.—On every switchboard there should be at least two instruments, one a voltmeter for showing the pressure of the current in volts, and the other an ampere meter, or shortly an ammeter, recording the quantity of current in amperes. Often each main circuit from the switchboard has its own ammeter and by this means we can tell when any individual circuit is taking more than what we know to be its normal amount.

296. Many ocean-going steamers are fitted with hydraulic cranes, etc. Where do they obtain their power? How is the hydraulic pressure kept at a relatively constant amount?

Ans.—For a ship installation recourse is had to a steam loaded piston to obtain the hydraulic pressure; thus a steam cylinder is mounted

directly above a ram chamber and the piston rod forms the ram itself. Steam at from 80 to 100 lbs. per square inch is admitted on top of the piston and as the piston is 10 times the area of the ram, the water pressure is from 800 to 1000 lbs. per square inch. From the lower



Fig. 122.

part of the ram chamber a pipe leads the high pressure water away to the cranes, and on the opposite side another pipe allows the water from the pumps to enter ram chamber. The function of these double acting pumps is to force water into the chamber against the pressure of the steam on top of piston, so that when the cranes take the high pressure

away and thus allow the ram and piston to descend, the pumps shall set away and force in water from their feed tank, to which tank the exhaust water from cranes is returned. As the piston descends it uncovers a port and pipe leading to the steam chests of the pump

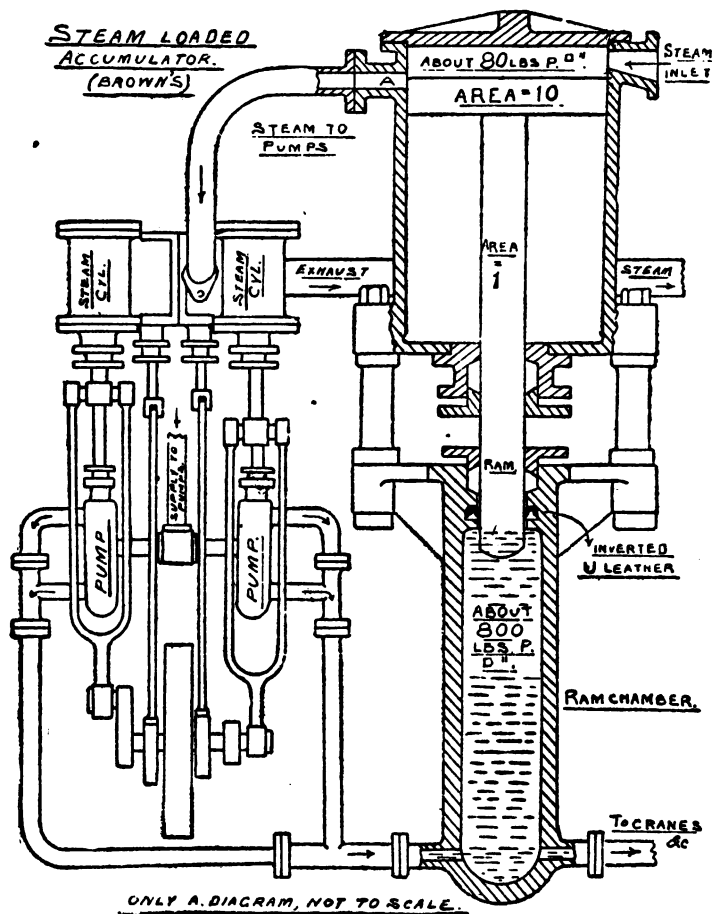


FIG. 123.

cylinders and thus these receive their working steam. When cranes are stopped, the pumps go on working until they have sent into ram chamber such an amount of water as lifts the piston high enough to close the steam supply port to them, on which they also stop, but as the steam still presses on top of piston, the water remains in the ram

chamber ready for instant use at the high pressure. The pressure is thus kept practically constant by the combined effects of the steam load and the pumps supplying water. In some cases the pumps do not actually stop, but go on working very slowly, the water they send out being bye-passed back to the tank. This avoids shock on the pumps. (See fig. 123.)

297. Is any difficulty experienced in working hydraulic cranes in frosty weather? If so, why?

Ans.—Whenever the temperature falls below zero, there is risk of the system freezing up if the water be kept fresh, but as the result of adding certain chemicals to water is to lower the freezing point of the mixture, make a solution of water and calcium chloride (chloride of lime) to such a strength that one gallon weighs about 11 to 12 lbs., according to the coldness of the climate. Common salt will also answer, but is productive of more rusting than is the lime. Further, in some high-class vessels, glycerine is added, but this suffers deterioration through time and goes bad with a very offensive smell. If far distant cranes are kept in motion there is less liability to freeze, as the water is moving, but this entails constant extra expense and labour.

297. ALTERNATIVE SETTING.—How does frosty weather prevent a hydraulic system from giving its full efficiency? What can be done to prevent the trouble?

Ans.—(That already given will do.)

298. Describe any steam steering gear you are acquainted with.

Ans.—(*Note by Author.*—The candidate in answering this question should do so by describing the particular gear he has been used with as, presumably, he understands that type the best. The following applies to Alley & MacLellan's horizontal type and shows the kind of answer desired at the examination).

This form of gear consists of a chain drum driven by a large worm wheel and worm, which worm is operated by the cylinders, etc., of the steering engine, being keyed upon the common crank shaft. Each cylinder has one valve, eccentric rod and fixed sheave, and coming between the chests of the two cylinders is the "control" valve and its chest. The engine is enabled to reverse even though the single sheave be fixed, as the following explains. The control valve is moved by the

steering wheel operated by the steersman and turned in one direction; it admits steam over the outer edges of engine valves, but when turned oppositely it admits the steam over their *inner* edges, and as the one sheave for each engine valve is keyed on the shaft at 90° to its crank, this changing of the steam admission results in reversal of the engine. When the engine is running it always tries to bring the control valve back to mid position and so stop itself, and if it is wished to keep the gear working the steersman must keep on turning his hand wheel so as to keep the control valve open at the point he originally got it to at first starting, with engine at rest.

Note by Author.—All readers should carefully study Plate XIV., which gives excellent information regarding the "Hunting" gear of one of Alley & MacLellan's steam steering gears; and figures 124 and 125 are worthy of close attention. The returning of the control valve to its central position must be understood by all candidates.

299. When the helm is put hard over and the ship is going full speed ahead, what prevents the rudder returning to the amidship position?

Ans.—When a pull comes on the steering chains in a reverse direction and the barrel would like to turn under such pull, it is prevented by the locking effect of the worm and worm wheel. The latter cannot turn the former, because its teeth are so nearly at right angles to the axis of the worm. The effort to do so, however, sets up a heavy stress or thrust through the worm shaft which is taken by either small thrust blocks built into engine framing, or by stiffening the shaft bearings.

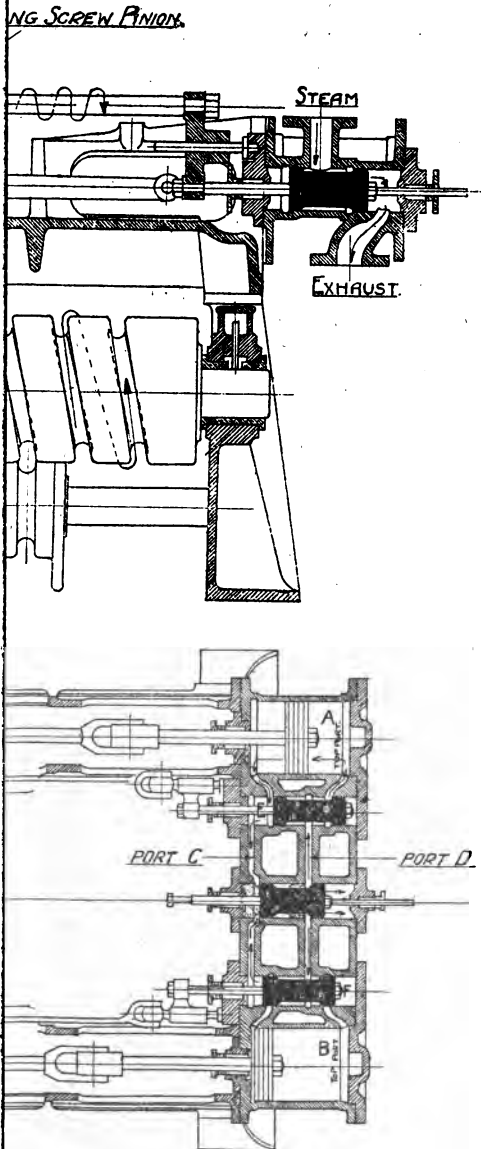
300. In the case of a steamship under way does the officer or man manipulating the steam steering wheel overcome any resistance exerted by the rudder?

Ans.—As the steering wheel only operates the control valve through a system of rods, levers and fair leaders, the only resistance felt by the steersman is the friction of these and of the spindle of the valve in its stuffing box, all of which is in a well-arranged installation, very little. He feels *none* of the resistance due to moving the rudder.

300. ALTERNATIVE SETTING.—What makes the resistance to motion of the steam steering wheel? Does a large rudder mean more of this resistance than a small one?

Ans.—(That already given will do.)

No. 2 DIAGRAM.



If the control valve be moved until it takes up the position shown, steam will enter port D and round main valves into the top ports of cylinders A, B. The exhaust passes along port C and up through the control valve.

If the control valve be moved into the position shown by dotted lines, steam will enter port C and then into the bottom ports of cylinders A, B, thus reversing the motion of the gear. The exhaust will pass out through port D.

When the gear is in motion, the worm turns the hunting screw pinion and it draws the spindle back by means of its screw, until the control valve covers ports C, D, thus shutting off the steam. It will therefore be seen that it is necessary to keep turning the steering wheel in order to keep the gear in motion.

Note by Author.—Observe that now the engine is standing and ready to start off in a contra clockwise direction, whereas in No. 1 diagram she was standing and ready to move off clockwise.

FIG. 125.

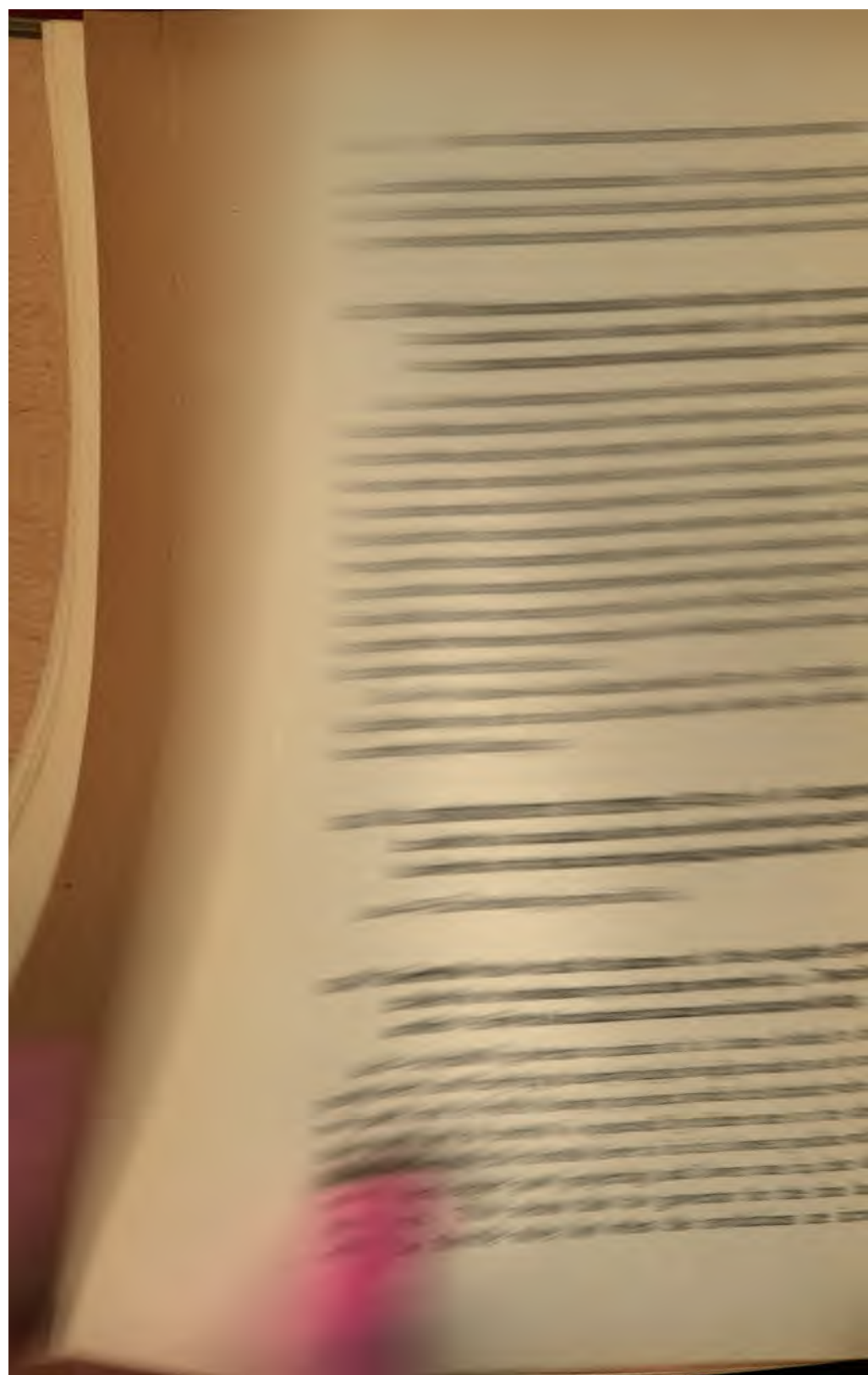
301. Explain clearly what is being done by a helmsman manipulating the wheel of a steam steering engine.

Ans.—When the hand wheel is turned, let us say to starboard, it by means of the rods, levers and fair leaders, moves the control valve (which always has its steam over the one edge) such as to admit steam over the outer edges of the engine valves, and, in consequence, the gear runs with the sheaves at 90° leading the cranks. When the engine turns, a worm wheel engaging with the worm is revolved upon the spindle (Hunting screw pinion) which actuates the control valve and as this wheel acts as a long nut, being only capable of turning round, it screws the spindle through itself in such a direction as tends to close the control valve. If helm be over sufficiently, the steersman stops turning his wheel, when the “Hunting” gear, just described, gains the mastery and runs the control valve back to mid-position, thus stopping the gear. It will be noticed from this that a steam steering engine cannot stop *instantly* the hand wheel is held stationary and though the additional movement is not much, yet it should be allowed for, especially if all connections between chain on drum and tiller are well set up.

Note by Author.—Plate XIV. should be studied again for “Hunting” gear details.

302. Is there any difference between the amount of horse power required to put a helm hard over, in a given time, when the vessel is going full speed ahead, and when she is going full speed astern? This question refers to the case of a steamer fitted with one rudder only, and demands a more complete answer than merely “yes” or “no.”

Ans.—There is greater effort needed to bring a rudder from the midship position to any certain angle when going ahead, than there is when going astern, for the following reason. The propeller, driving *aft* its stream when the vessel goes ahead, does so at a greater speed than the ship herself travels at, consequently the rudder, coming over against this stream, finds more resistance than what it does in being *brought back* to the midship position, with vessel travelling sternwards, as then it only meets a resistance due to the ship's speed. The effort required to move the rudder depends upon the square feet area of immersed rudder, the speed of the stream it comes against and the angle to which we require to fetch it over and the greatest force needed is as explained above, but in this case the rudder *comes back* to its mid-position easily,



such that the fall of the lever is about 5% faster than its normal speed, the weight, due to its inertia, is left behind and so causes the lower pawl to be brought sufficiently out to engage with the arm that controls the throttle valve, when the lever makes its next *up* stroke, and the weight is kept there by a "detent" holding it. This closes the throttle and hence the revolutions fall. On the return stroke the detent is lifted by passing throttle lever and so frees the heavy weight, which, if racing be over, falls and reverses the positions of the pawls, the top one now projecting and catching throttle lever lowers this and so opens the

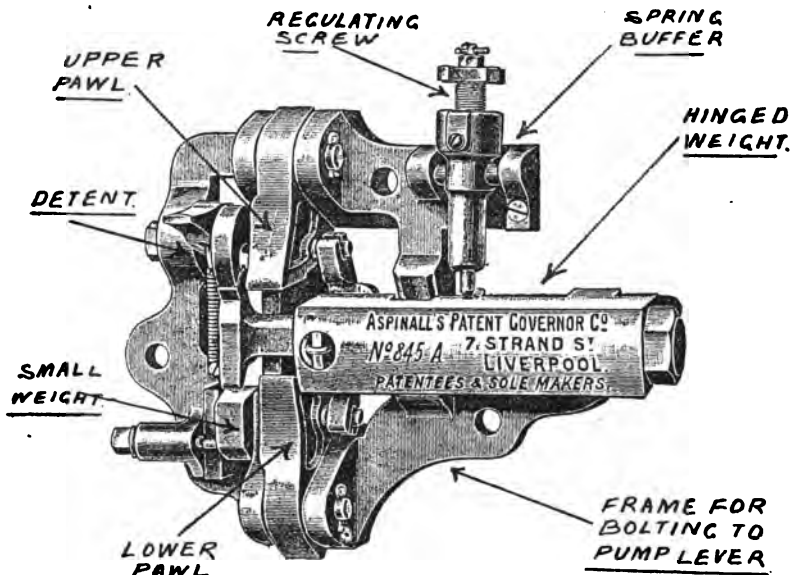


FIG. 126.

valve again. If racing is not over, the pawls remain as they were when the throttle valve was shut.

In the event of the shaft breaking or other cause for excessive speed of lever, a small or emergency weight comes into operation by being left behind and so locks the heavy weight in the shut off position and only when this severe race is over can the small weight be released by hand.

It will be seen from this description that the Aspinall governor partakes of the "all or nothing" form, as either the steam is on or it is off.

Note by Author.—We have only given these particulars and illustra-

tions because we know many candidates will have been with this type of governor and so will be the better placed for answering the question from their own first hand knowledge, but should the particular reader not have been with *any* governor at all, we advise his reading what we have written in connection with question.

Note.—The following six questions refer to oil motors fitted to launches which carry passengers.

305. Name the principal parts of an oil motor, and briefly state their functions. Give the name of the makers of the motor.

Ans.—The following comprise the principal parts of an oil motor as fitted in launches. One or more cylinders, water jacketed, mounted

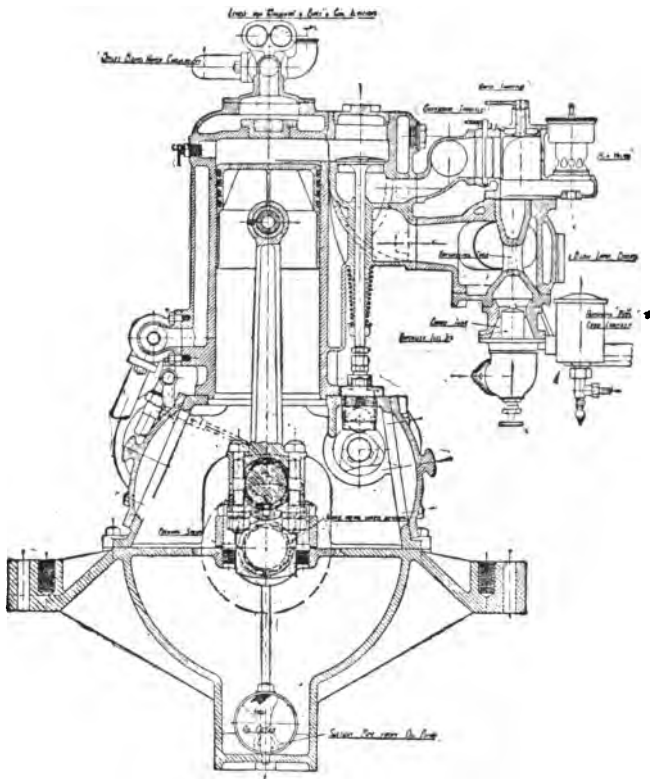


FIG. 129.

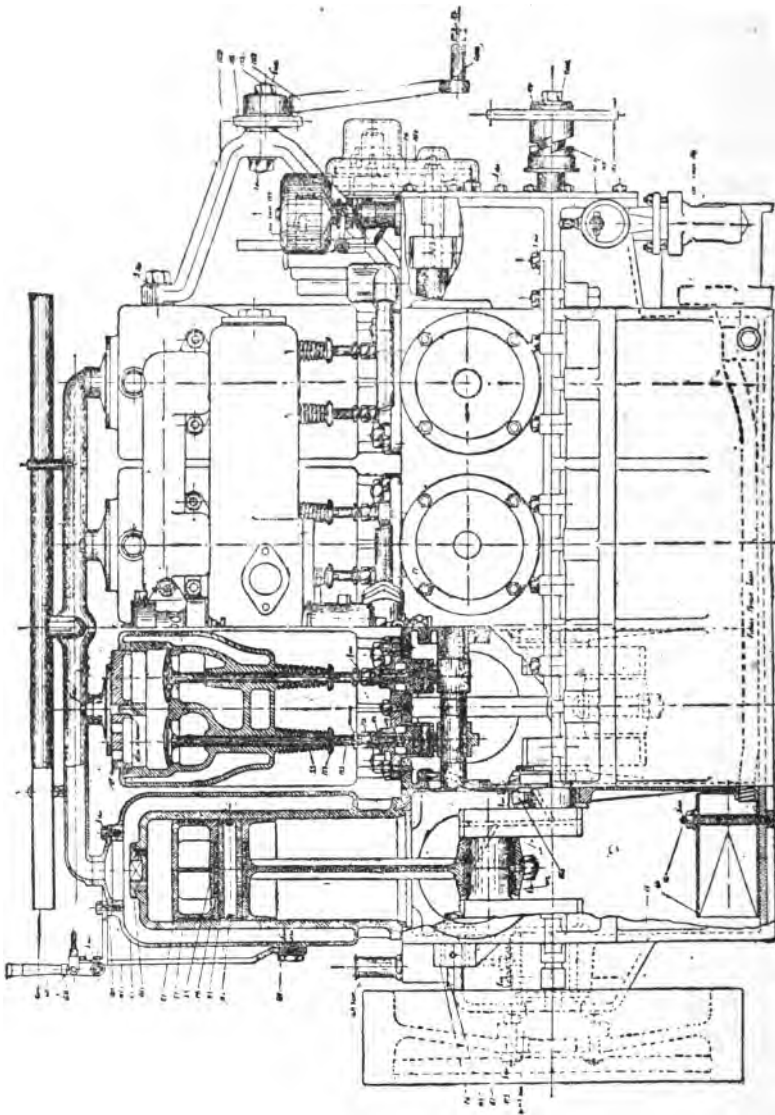


FIG. 130.

Figs. 129 and 130 show sections of one of Messrs. Parson's motors of 60 horse power.

upon a crank case carrying the main bearings and crank shaft. Each cylinder has a long trunk piston kept tight by Ramsbottom packing rings and which piston has a gudgeon pin taking the small end of the connecting rod, whose bottom end embraces the crank pin as usual. The top of the cylinder carries the sparking plug for ignition as well as covers over the inlet and exhaust valves. These are mushroom valves whose spindles have strong springs to bring them back on to the seats

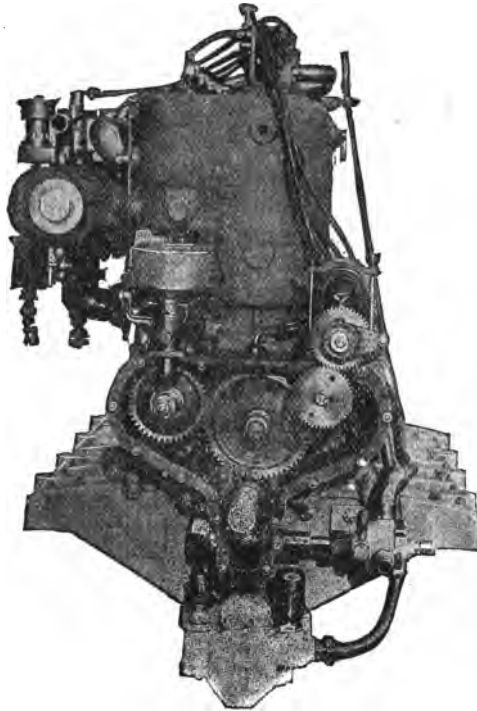


FIG. 131.—End elevation of a Parsons motor showing gear wheels.

as each valve is pushed up by rods worked by cams on a "cam shaft," which runs parallel to the crank shaft and is driven at half the speed of latter by means of gear wheels, one on each shaft, that on the crank this being of half the number of teeth to that on cam shaft. To supply the working "mixture" a carburettor is supplied, into which the petrol flows and becomes vaporised, partly by its volatile nature and further by placing the carburettor near the exhaust pipe, the heated air round

about causes the petrol to be *rapidly* gasified. Air being allowed to mix with this vapour, in the carburettor forms the "mixture" which passes by a pipe to the underside of the inlet valve, and hence on this

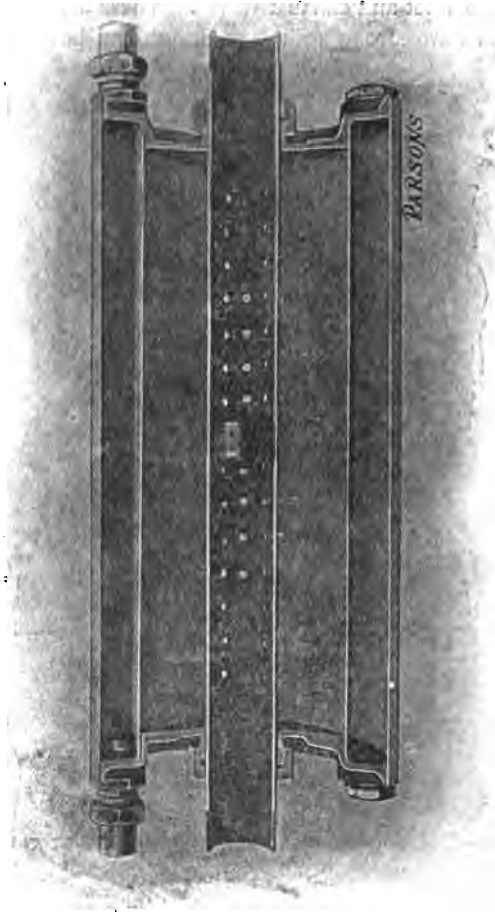


FIG. 132.

opening it passes into the cylinder. The waste or exhaust products in turn pass the exhaust valve and away to a "silencer" in which by successive expansions and contractions they drop very much in pressure and temperature and finally issue to the atmosphere. (See fig. 132.)

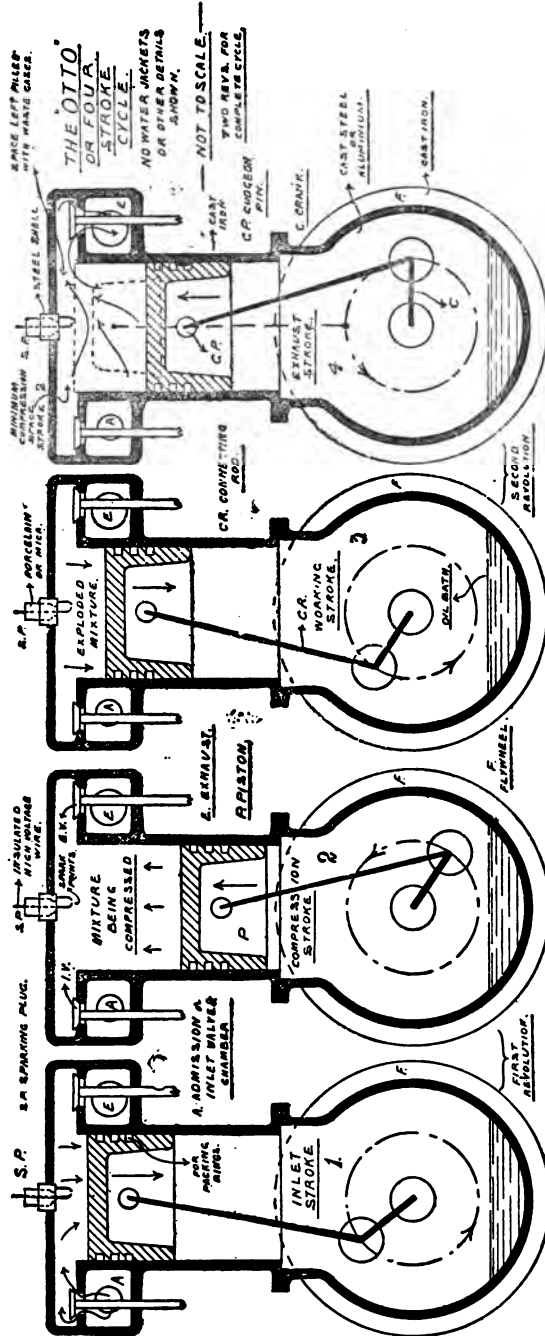


FIG. 133.

To supply the necessary high voltage electrical current to the "sparking" plug, there is fitted either an induction coil and accumulators or else a magneto, and if the former, a special contact maker is supplied whose moving part revolves from the cam shaft and thus completes the circuit between accumulator coil and plug only once in every two revolutions.

Note by Author.—The block, fig. 133, shows the four strokes comprising the "Otto cycle" of the majority of these engines. The diagram is self-explanatory, but in order to store sufficient energy for strokes 1, 2 and 4, as well as render the turning effort more uniform, a heavy flywheel is fitted.

Plate 15 shows two views of one of Messrs. Brazil, Straker & Co.'s marine motors of 15 B.H.P. at 800 R.P.M. Fuel is ordinary petroleum, and at full load the consumption is 1 gallon per hour, and of lubricating oil about $\frac{1}{4}$ pint per hour. Starting is on petrol, or a hand lamp can be used giving a start from all cold in 3 minutes. The vaporisers are hot enough to restart engine after she has stopped for 30 minutes.

306. What kind of oil is usually employed in oil motors? What is its flash point? What is its specific gravity? What is its calorific power? What precautions are taken in its storage to guard the public against casualty by fire or explosion?

Ans.—The commonest fuel is petrol, which is a species of petroleum spirit partaking somewhat of the properties of both. It is extremely volatile and will vaporise on its own, but where the quickest gasifying is needed as with these very high speed motors, a slight warming is beneficial. Paraffin oil is also coming more and more into use as a fuel on engines of a rather large size.

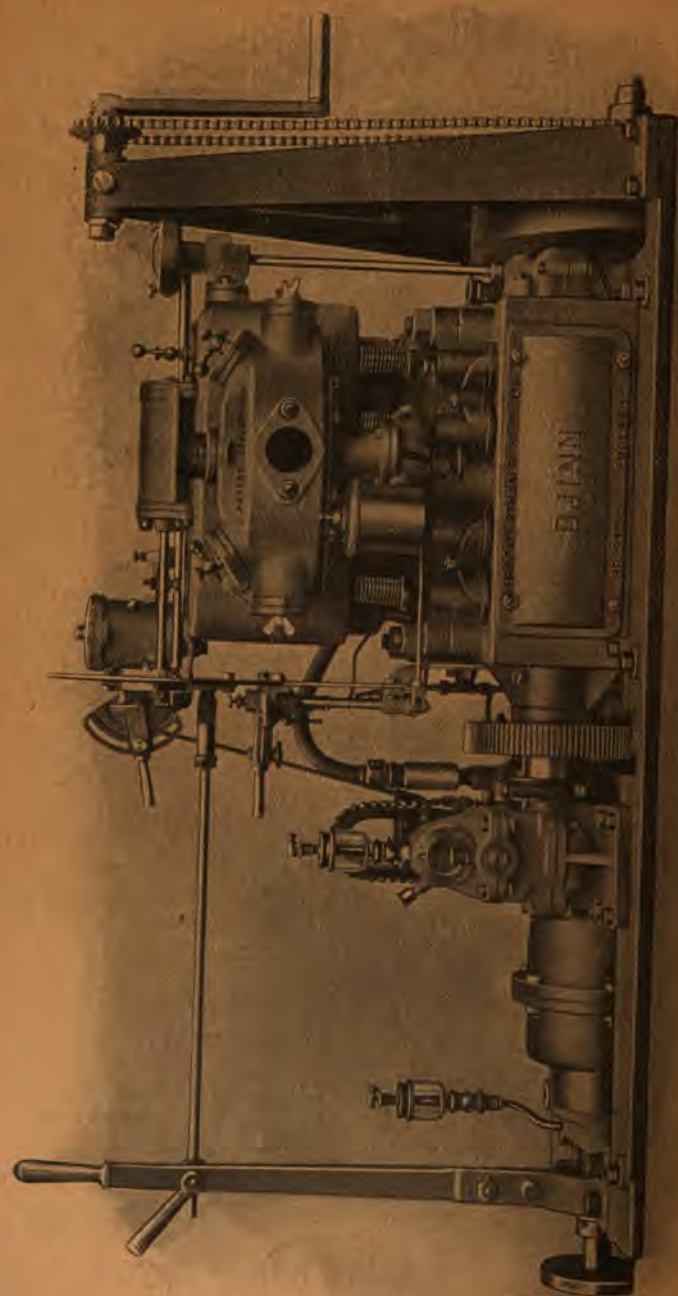
The flash point of petrol is about 73° but varies a little with the different brands, that of paraffin oil being about 90° .

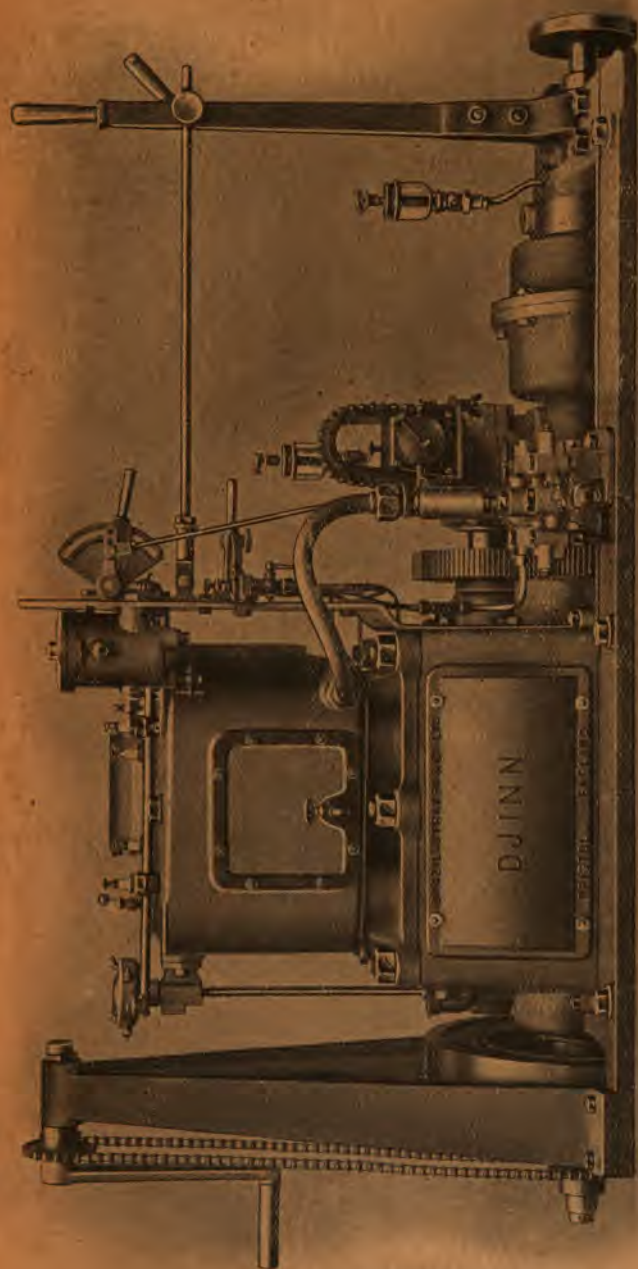
The specific gravity of petrol ranges between .65 and .75, whilst paraffin oil is heavier being about .78 to .83, and means that an equal volume will only weigh from .78 to .83 that of fresh water.

The calorific value is also a variable, but for petrol, about 19,800 B.T.U.s. per lb. may be taken and for paraffin a little higher, about 20,000 B.T.U.s. per lb.

All petrol and paraffin must be stored in places away from heat and

PLATE XV.





To face page 242.

the chance of damage to the drums or other containing vessels. These latter should be of brass or copper, as iron or steel rusts in course of time under the effect of the oil, but as the former metals are too costly resource is had to good mild steel, and the tanks periodically inspected carefully to see that corrosion has not developed to a dangerous extent. They must be fitted with filling plugs capable of being made air-tight when motor is not in use, but means must be provided whereby atmospheric pressure may be allowed in, so as to cause the petrol, etc., to flow to carburettor when the suction from the engine sets up a partial vacuum. If, however, the oil is supplied under pressure to the carburettor, as is common at the present day, there is, of course, no opening left to the air, but a hand force pump is supplied to obtain the requisite air pressure. The storage tanks are never completely filled, a small space being left for expansion of the liquid in case the tank becomes accidentally heated.

306. ALTERNATIVE SETTING.—Which has the greater heating power, petroleum or petrol, and what is the gain by the one? What is the correct name for "heating" value? When we speak of specific gravity, what is meant?

Ans.—(That already given will do.)

307. How many cylinders are generally used in oil motors? What kind of pistons are fitted? How frequently (measured in revolutions) is explosion per cylinder effected? How is explosion in the cylinder carried out?

Ans.—The number of cylinders varies with the total horse power of the motor, there usually being one for small powers up to about 4 horse power, 2 cylinders for about 12 to 20 horse power, 4 cylinders for 30 to 45 horse power and 6 cylinders for horse powers of about 50 to 65, though these figures vary considerably with different builders.

The pistons fitted are all of the "trunk" type (see figs. 129 and 130), being practically the same length as diameter and this is required because they have to take the place of a crosshead and guide bars, these parts being absent in oil motors as we are describing. To ensure tightness against the compression and explosion in the cylinder,

grooves are turned in the cast iron of the piston and ordinary Ramsbottom packing rings (3, 4, or 5 in number) are inserted.

If the motor is a four stroke cycle and runs ungoverned there will be an explosion every *second* revolution, viz., at the start of every *second* stroke downwards, i.e., the third stroke of the four going to make the Otto cycle. If the motor be a two-cycle or two-stroke one, the explosion occurs at start of *every* downstroke.

The explosion is brought about usually by electrical means such as

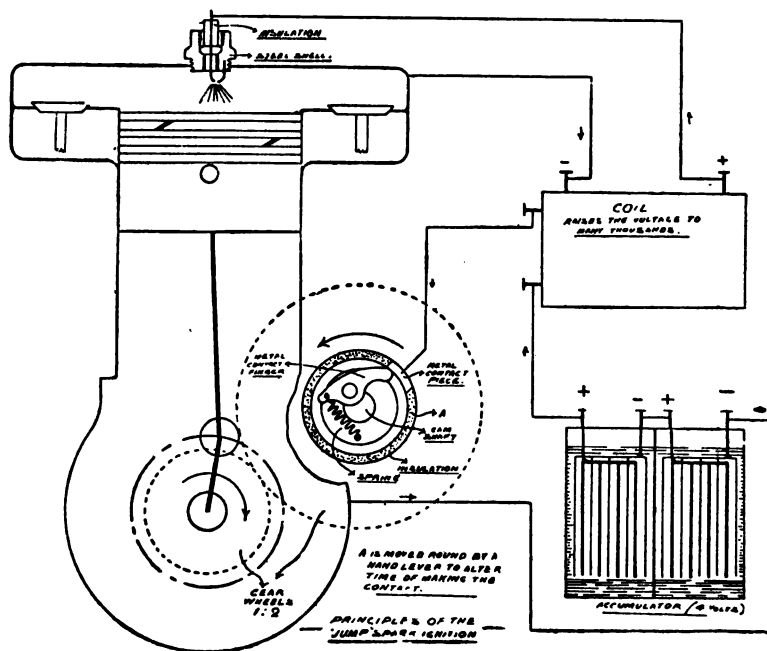


FIG. 134.

an accumulator battery of two cells, an intensity coil to raise the voltage, and a sparking plug, or else a magneto generator driven by the engine is used to supply current.

The former consists of two accumulators charged with continuous current and coupled in series so as to give about 4 volts; this current is sent round a "primary" winding in the "intensity" coil, being governed in its passage by the "contact maker" driven off the cam or half speed shaft of the motor. Surrounding the primary wire but

insulated therefrom is wound a large quantity of the very fine or high tension wire, and as the primary current is sent pulsing through its wire it "induces" a *very high* voltage current to pass from one end of the fine wire to the central wire of the sparking plug and the voltage being sufficient for it to jump the little gap at the points of this plug it creates a spark in so doing and returns by the steel shell of plug, engine itself and another wire leading back to the other end of the fine or "secondary" winding on the coil. (See fig. 134.)

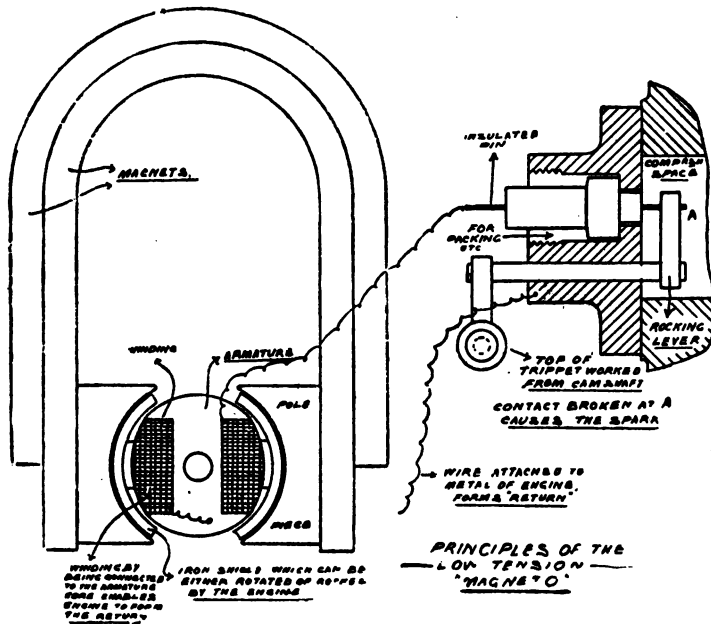


FIG. 135.

Magneto ignition may consist of a small permanent magnet dynamo supplying current to its own self-contained intensity coil and thence away from this to the ordinary sparking plug, or it may be what is called a "low tension" magneto wherein a shield of soft iron is rocked to and fro between the armature and pole pieces and by so doing sets up a rise and fall in the current induced in the armature wires. When this current is at its maximum a contact is *broken* and the act of rupturing causes the voltage to momentarily rise sufficiently high that

a spark may form against the force of the compressed mixture and thus this latter is fired or exploded. Means are provided whereby in either system the time of firing may be advanced as the engine accelerates or retarded as it slows down, in order to prevent a "pre-fire."

307. ALTERNATIVE SETTING.—Are these engines single or double acting usually? What limits the horse power from any one cylinder?

Ans.—The majority of these engines are only single acting, *i.e.*, they get the impulse always on the same side (top side) of piston, but in a very few cases, and only where the engine is large are they double acting. Horse power from a single cylinder cannot become very great as the *initial load* upon all bearing surfaces would then be far in excess of safe practice and lubrication.

308. Describe how an oil motor is started. If starting prove difficult, where would you chiefly look for defects? How is piston speed modified? How is the speed of the vessel varied? How is reversing effected?

Ans.—Before starting an oil motor observe that the clutch is free, *i.e.*, that the screw does *not* revolve with the engine. (*See* fig. 136.) Then open the sea water on to the pump which circulates it through the jackets of the cylinders. Test accumulators (if these be used) to see voltage is between 3.6 and 4. Open petrol on to carburettor and flood this latter. See that switch on primary wire from battery is closed, and if the motor is anyway large, either open a trifle the small cocks inserted in cylinder heads, or move along into position underneath the spindles of the exhaust valves, the "half compression" cams and as either of these methods releases some of the compression the motor can be given a few *quick* turns by means of the handle engaging with the crank shaft, when it should at once start off. Should it not do so, however, examine the petrol tank to see if there be oil in it, also cocks and up to the carburettor, then all wiring from either cells and coil or magneto up to and including the spark plug. Be sure the points of this are not incrustated with greasy carbon deposits. Note that all valves are lifting and *closing* at their proper times and see that the compression is good.

Variation of piston speed means at once variation in ship's speed and is brought about by any or all of the following. To decrease speed, reduce quantity of petrol or throttle down the mixture, retard time of sparking and to increase speed, give a little more petrol (but do not richen mixture too much), open out throttle, etc., or advance time of sparking.

Reversing can be effected by either a reversing gear, or else by a propeller having loose blades which can be turned from the headway position to a similar one at the opposite angle, for the sternway.

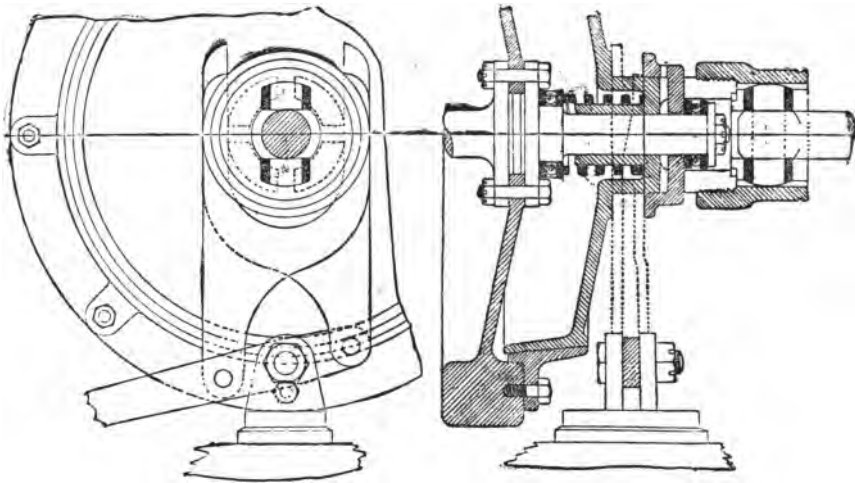


FIG. 136.

Note by Author.—Description of Parsons reversing gear. The figs. 137 and 138 show the gear box opened and the gear in headway position (fig. 137). It consists of a small piece of shafting having a large square upon it which carries a square jaw muf forming part of a coupling, and this is seen at the centre and *right hand* of the figure. The gear wheel seen there is loose upon the shaft but can be connected to it by moving the coupling to the right. The other part of the main shafting goes out to the left and has a thrust collar upon it and also carries a gear wheel solid with it. The side shaft has a large square, as seen, upon which slides a wheel, while the other one is fastened to the side shaft. Below in the box is a smaller wheel which conveys the motion of the engine shaft wheel (when this is driven) to the side shaft

wheel and in order to make the operation of reversing clear to candidates, let us take it that the screw is at present going ahead, for

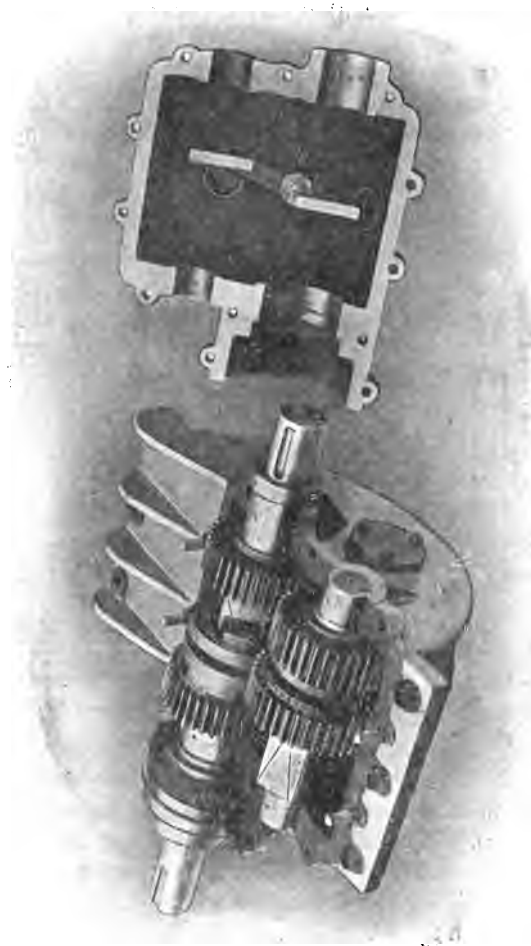


FIG. 137.

this, the coupling engages with the thrust shaft wheel and so the engine and screw shafts turn *as one*, and to reverse, the hand lever is moved and this by means of the levers inside the top half of box,

moves the coupling away from the thrust shaft wheel, and on to the loose engine shaft one, resulting in this latter *turning* the way the engine runs. At the same time the other arm has moved the free

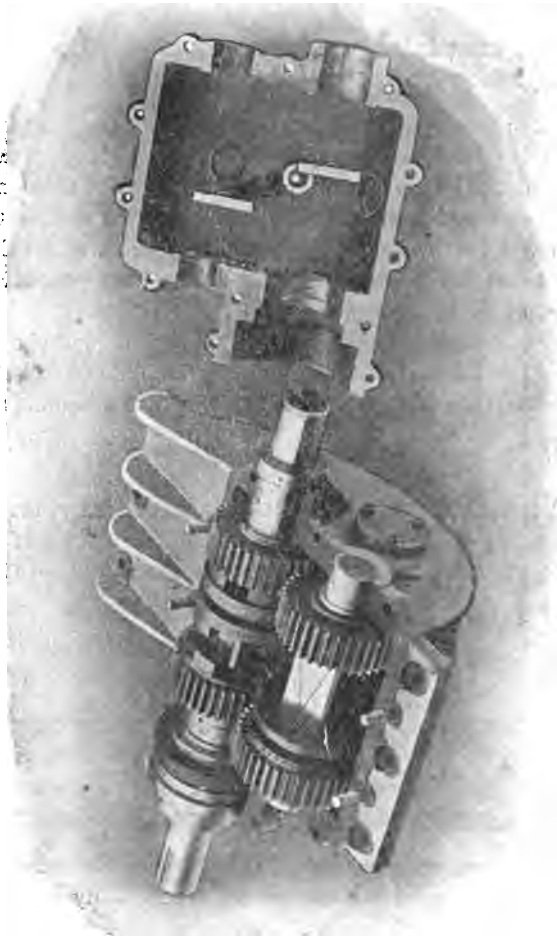


FIG. 138.

wheel on the side shaft into mesh with the thrust shaft wheel and we have the gear as in fig. 138. The engine, remember, runs the same way as at first and its wheel being now compelled to turn, drives the

smaller wheel in bottom of box and this meshes into the fixed "side shaft" wheel and turns this the *same way* as the engine. The result of which is that at the thrust end the main shaft revolves *oppositely* to the engine shaft and we have reversed.

309. Before examining an oil motor with a naked light, what steps should be taken for safety's sake?

Ans.—By rights no naked lights should be brought near a motor after it has been running, use only electric hand lamps, but if naked lights are found to be the only ones available, then see the petrol supply is shut off, carburettor emptied and drip trays also. Next give the engine a few turns by hand, with the compression released, this will enable air to be drawn in and expelled and so sweep out the cylinders and of any lurking gas.

If going to examine motor as soon as it stops, a good plan is to shut off petrol or paraffin and let the engine run itself down to a stop and it will thus exhaust the pipes and cylinders of gas or mixture.

309. ALTERNATIVE SETTING.—Is there any risk in examining an oil engine or petrol motor with a naked light? What can you do to prevent accidents?

Ans.—(That already given will do.)

810. How frequently should an oil motor, working 12 hours a day, be opened up for examination, cleaned, and its parts readjusted? What difficulty arises when the internal parts become foul with carbonised oil?

Ans.—The correct answering of this question depends really upon the daily attention paid the engine and the quality of the oil and amount used for its lubrication. Assuming all the electrical leads, contact maker and carburettor are looked after each day before starting, as well as giving the exhaust valve a few turns on its seat, the sparking plug removed at least once a week and its points examined and if encrusted, this deposit removed, the engine should run for several weeks before it needs any heavy overhaul. If, however, the lubricating

oil has been used too freely and especially if of rather a poor quality, it will form a heavy greasy deposit on piston top, cylinder head and compression space and as this becomes very hot it leads to the mixture pre-firing, with consequent shock on the engine and loss of work. Further, this deposit means less mixture drawn in, due to the restricted volume.

310. ALTERNATIVE SETTING.—Does the behaviour of a petrol motor tell you anything as to her need for cleaning?

Ans.—Yes; because if dirty the engine will run badly, misfire frequently, adjustments soon altering, heavy wear and tear, loss of power and generally run in any way but the right one.

REGULATIONS

RELATING TO THE

EXAMINATION OF ENGINEERS.

CHAPTER I.

GENERAL RULES.

1. Authority for Regulations.—These regulations are issued in pursuance of the Merchant Shipping Act, 1894 (57 and 58 Vict., c. 60).

In accordance with section 92 of that Act, "every British foreign-going ship* and every British home-trade passenger ship,* when going to sea from any place in the United Kingdom, and every foreign steamship carrying passengers between places in the United Kingdom, shall be provided with officers duly certificated under this Act according to the following scale :—

* * * *

- (d) If the ship is a foreign-going steamship of one hundred nominal horse-power or upwards, with at least two engineers, one of whom shall be a first-class, and the other a first-class or second-class engineer, duly certificated.
- (e) If the ship is a foreign-going steamship of less than one hundred nominal horse-power, or a sea-going home-trade passenger steamship, with at least one engineer who is a first-class or second-class engineer duly certificated."

An officer is not duly certificated unless he is the holder for the time being of a valid certificate under the Merchant Shipping Act of a grade appropriate to his station in the ship, or of a higher grade.

* "Foreign-going ship" includes every ship employed in trading or going between some place or places in the United Kingdom, and some place or places situate beyond the following limits; that is to say, the coasts of the United Kingdom, the Channel Islands, and Isle of Man, and the Continent of Europe between the River Elbe and Brest inclusive. "Home-trade ship" includes every ship employed in trading or going within the following limits; that is to say, the United Kingdom, the Channel Islands, and Isle of Man, and the Continent of Europe between the River Elbe and Brest inclusive. "Home-trade passenger ship" means every home-trade ship employed in carrying passengers.

If any person, having been engaged as one of the above-mentioned officers, goes to sea as such officer without being duly certificated, or employs a person as an officer, in contravention of the above provisions of the Merchant Shipping Act, without ascertaining that the person so serving is duly certificated, that person shall be liable for each offence to a fine not exceeding fifty pounds.

By section 96 of the same Act provision is made for holding examinations for the grant of certificates of competency, and power is given to the Board of Trade to regulate the conduct of the examinations and the qualification of the applicants.

2. Time and Place of Examinations.—The times and places at which examinations are held are shown in Appendix A, of these Regs.

3. How to Apply.—Candidates for examination must fill up a form of application (form Exn. 3) at a Mercantile Marine Office. The form, properly filled in, together with the candidate's certificate of apprenticeship, testimonials, and discharges, must be lodged with the local Examiner of Engineers not later than the day before the day of examination, except in the case of London and Liverpool.* As discharges and testimonials may have to be forwarded to the Registrar-General of Seamen for verification, it is desirable that they should be handed in, together with the form of application, as many days as possible before the date of the examination which the candidate desires to attend. In the absence of the necessary verification the candidate cannot be examined.

In all cases in which certificates of discharge in the home or other trade which have not been officially issued at a Mercantile Marine Office are produced as evidence of any part of a candidate's qualifying service, they should be submitted to the Registrar-General of Seamen for verification.

4. Gaps in Service.—The examiner should be particularly careful to ascertain that there are no gaps in the candidate's service which are not properly accounted for before he is allowed up for examination.

5. Calculation of Service.—The candidate's service, as shown on his discharges, should be reckoned by the calendar month, *i.e.*, the time included between any given day in any month and the preceding day of the following month, both inclusive. The number of complete months from the commencement of the period, ascertained in this way, should be computed, after which the number of odd days should be counted. The day on which the agreement commences as well as that

* At London applications for examination must be made on Fridays or Saturdays during office hours; at Liverpool on Mondays or Saturdays during office hours.

on which it terminates should both be included, and all odd days should be added together and reckoned at 30 to the month.

6. Service must be Verified.—Service which cannot be verified by proper entries in the articles of agreement of the ships in which the candidates have served cannot be counted.

7. Application in Special Cases.—In cases where the services of a candidate require verification, or where he is in doubt whether his service complies with the regulations and wishes to submit his case for special consideration, all certificates, discharges, and testimonials, together with the form of application,* properly filled in, should be submitted to the local Examiner of Engineers. If necessary the examiner will, after seeing that all the required information is clearly stated in the papers, forward them with his observations to the Registrar-General of Seamen, who will either deal with the case or transmit it to the Board of Trade for decision.

8. Inquiries.—All other inquiries regarding examinations should be made and dealt with in the same way. The point on which information is sought should be clearly stated, and certificates, discharges, testimonials, etc., should be forwarded when they are material to the inquiry.

9. Age.—Should any doubt exist as to the age of a candidate, he will be required to produce a certificate of birth.

10. Fraud and Misrepresentation.—It is provided by section 104 of the Merchant Shipping Act, 1894, that any person who makes, assists in making, or procures to be made, any false representation for the purpose of procuring either for himself or for any other person a certificate of competency, shall in respect of each offence be guilty of a misdemeanour, which is punishable, on summary conviction, with imprisonment for a term not exceeding six months, with or without hard labour, or with a fine not exceeding one hundred pounds.

11. Testimonials; Shore Service.—All candidates will be required to produce, in addition to the official discharge certificates, testimonials as to their workshop service and as to their service at sea. The testimonials as to workshop service must be signed by the employer, and must testify to the candidate's conduct and ability, and state what kind of work he was engaged on (*e.g.*, fitting, erecting, turning, machine work, etc.), and for how long. (*See* paragraph 36.)

12. Testimonials; Sea Service.—Testimonials as to service at sea must testify to the applicant's sobriety, experience, ability, and general good conduct for at least the last twelve months' service at sea

* Form Exn. 3, which can be obtained at any Mercantile Marine Office.

preceding the date of application to be examined.* They must be signed by the master and chief engineer, or, in the case of testimonials to chief engineers, by the master and superintending engineer, and must clearly state whether the applicant was on regular watch, and in regular charge of a watch on the main engines or boilers. It is desirable that testimonials of candidates should be endorsed by the superintending engineer. No time spent in clerical work will be allowed to count.

13. Further as to Testimonials.—In cases where a testimonial from the chief engineer or from the master is for any sufficient reason not obtainable, one may be submitted from the superintending engineer in place of that of the chief engineer, and from the marine superintendent in place of that of the master, or from the managing owner or secretary or chairman of a large company in place of either; but in every such instance the testimonial must declare that the facts stated are in accordance with the reports made by the chief engineer or the master, as the case may be, or else that the facts are within the writer's personal knowledge.

14. Penalty for Misconduct.—Candidates who have neglected to join their vessels after having signed articles, or who have deserted their vessels after having joined, or who have been found guilty of gross misconduct on board, will be required to produce satisfactory proofs of two years' subsequent service and good conduct at sea, unless the Board of Trade, after having investigated the matter, should see fit to reduce the time.

15. Physical Defects.—When a candidate is observed to be hard of hearing, or is labouring under any other obvious physical defect, the signatories of his testimonials are required to mention that defect specifically, and to state whether it in any way interfered with the efficiency of the candidate as an engineer on watch. When these modified testimonials are such as to completely satisfy the examiner that the defect is not such as to interfere with the efficient discharge of the applicant's duties as engineer, the examination is proceeded with; otherwise the case is referred to the Board of Trade. Candidates afflicted with nervous impediment in speech may write their answers to *viva voce* questions.

16. Foreign Service.—The testimonials of service of foreign or British engineers serving in foreign vessels, which cannot be verified by the Registrar-General of Seamen, must be confirmed either by the

* *Note by Author.*—Candidates should here read the paragraph on sea service which follows paragraph No. 33 of these Regulations.

Consul of the country to which the ship in which the candidate served belonged, or by some other recognised official authority of that country; or by the testimony of some credible person on the spot having personal knowledge of the facts required to be established. The production, however, of such proofs will not of necessity be deemed sufficient. Each case must be decided on its own merits; and if the sufficiency of the proofs given appears to be at all doubtful the point must be referred to the Board of Trade.

17. Foreign Engineers must know English.—Foreign engineers must prove to the satisfaction of the examiners that they can speak and write the English language sufficiently well to perform the duties required of them on board a British vessel. In every case, before failing a candidate for insufficient knowledge of the English language, the examiner should refer the matter to the local Senior Examiner. Where the port has only one examiner, the matter should be referred to the Senior Examiner of the district, who, if the failure be confirmed, will endorse the report on the form Exn. 15.

18. Issue of Certificate.—If the candidate passes he will receive a form (form Exn. 16) authorising the Superintendent of the Mercantile Marine Office to whom it is addressed to issue the certificate. The candidate's testimonials and other papers will be returned to him when the examination is finished. It is therefore important that the port at which the certificate is to be issued should be the same on both the form Exn. 16 and the form of application, Exn. 3. If circumstances should make any alteration necessary, the examiner should see that it is made in both forms; otherwise delay in the issue of the certificate may be caused.

19. Service Found to be Insufficient.—If after a candidate has passed the examination it is discovered on further investigation that his services are insufficient to entitle him to receive a certificate of the grade for which he has passed, the certificate will not be granted to him; but if the Board of Trade are satisfied that the error in the calculation of the candidate's services did not occur through any fault or wilful misrepresentation on his part, he may either have the fee returned to him or have it placed to his credit. Should his services entitle him to a certificate of a lower grade it may be granted to him, and the difference, if any, between the fee paid by him for the superior certificate and the fee payable for the inferior certificate will be returned to him or placed to his credit. The superior certificate will not be granted until the candidate has performed the amount of service in which he was deficient, and has been re-examined in all the

subjects, unless the Board of Trade see fit to dispense with the re-examination.

20. Failure in Examination.—If the candidate fails in practical knowledge he may not present himself for re-examination until he can produce proofs of three months' further service at sea as engineer on watch on the main engines or boilers of a foreign-going steamer, or its equivalent in the home trade (four and a half months) subsequent to the date of failure. If he fails in arithmetic, elementary questions, or drawing only, he may come up again at any time, but in all cases of failure any re-examination must begin entirely afresh.

Failure in a number of elementary questions involving fundamental principles, or in questions ignorance of which might lead an engineer to do something actually unsafe in the management of any part of a ship's machinery, will be regarded as failure in practical knowledge.

21. Fee must be Paid.—Candidates for examination, in making their application on the form Exn. 3, will be required to pay the examination fee before any step is taken towards inquiring into their services or testing their qualifications, etc. If the candidate is found not to be qualified, the fee will either be returned to him or placed to his credit until he is qualified.

22. Payment of Fees, and Penalty for Offering Gratuity.—The fee for examination must be paid to the Superintendent of the Mercantile Marine Office in the cash office. If a candidate offers a gratuity to any servant of the department, he will be regarded as having committed an act of misconduct, and will be rejected, and not allowed to be examined for twelve months, either at the port where the offence was committed or at any other port.

23. Fees not Returned on Failure.—If a candidate fails in his examination no part of the fee he has paid will be returned to him.

24. Table of Fees.—The fees are as follows:—

Second-class engineer's certificate	-	-	-	£1	0	0
First-class engineer's certificate	-	-	-	2	0	0
First-class engineer's certificate, if the candidate holds a second-class certificate of competency granted by the Board of Trade or by the Government of a British Possession under the Merchant Shipping Act	-	-	-	1	0	0
Extra first-class engineer's certificate	-	-	-	1	0	0
Extra first-class engineer's certificate if the candidate has not been examined for and obtained a first-class certificate	-	-	-	3	0	0

CHAPTER II.

QUALIFICATIONS REQUIRED FOR THE VARIOUS GRADES.

Ordinary Certificates.

25. Value of Ordinary Certificates.—Ordinary certificates will entitle the holders to go to sea in the grade certified as engineers of any vessel in the British Mercantile Marine.

26. Second-class Engineer.—A candidate for a second-class engineer's certificate must not be less than 21 years of age ;

- (a) He must have served as an apprentice engineer for four years at least, and prove that during the period of his apprenticeship he has been employed in the manner set forth in paragraph 36 of the Regulations relating to the examination of engineers.

Journeyman's time will be considered as equivalent to apprenticeship.

Every applicant must produce testimonials of ability as a practical engineer to the satisfaction of the Board of Trade.

If the candidate has served as an apprentice engineer or as journeyman, under the conditions above prescribed, for less than four years, he will be required to make up the deficiency or to complete this period of four years by service as engineer at sea on regular watch on the main engines or boilers (1) of a foreign-going steamer of not less than 66 nominal horse-power, or (2) of a home-trade steamer of not less than 66 nominal horse-power, such service to be counted as equivalent in the case of (1) to two-thirds, and in the case of (2) to four-ninths, of service as apprentice engineer or as journeyman.

If the candidate has not served at all as apprentice engineer or as journeyman, he will be required to have served at sea, in lieu thereof, as engineer on regular watch on the main engines or boilers, six years in a foreign-going

steamer of not less than 66 nominal horse-power, or nine years in a home-trade steamer of not less than 66 nominal horse-power.

- (b) In addition to the apprenticeship as above described, or the alternative sea service, the applicant must have served eighteen months at sea as engineer on regular watch on the main engines or boilers of a foreign-going steamer of not less than 66 nominal horse-power; or twenty-seven months in a home-trade steamer of not less than 66 nominal horse-power.

(See also paragraphs 47, 48, 49, and 50 of the Regulations.)

- (c) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root. He must also be able to apply these rules to questions relating to safety valves, coal consumption, consumption of stores, capacities of tanks, bunkers, &c., and other similar problems; and be able to calculate the suitable working pressure for a steam boiler of given dimensions and the stress per square inch on crank and tunnel shafts and other parts of the machinery when the necessary data are furnished.
- (d) He must be able to pass a creditable examination as to the various designs of paddle and screw engines in general use, including turbines; as to the details of the different working parts, external and internal, and the use of each part.
- (e) He must have a satisfactory knowledge of the methods of construction of engines and boilers as used in the workshop, and of the attention required by the different parts of the machinery on board ship.
- (f) He must be able to give a satisfactory description of boilers, and the methods of staying them, together with the use and management of the different valves, cocks, pipes, and connexions.
- (g) He must understand the precautions necessary to be taken when raising steam in boilers and when opening stop valves to admit steam to pipes, etc.
- (h) He must understand how to make good the results of ordinary wear and tear to the machinery, how to correct defects from accident, decay, etc., and how a temporary or permanent repair could be effected in case of derangement or total break down.

- (i) He must understand the use of the water gauge, pressure gauge, barometer, thermometer, and salinometer, and the principles on which they are constructed.
- (j) He must be able to state the causes, effects, and usual remedies for incrustation and corrosion.
- (k) He must be able to explain the methods of testing and altering the setting of the slide valves, and methods of testing the fairness of shafts and adjusting them.
- (l) He must understand the construction and working of evaporators, feed filters, and feed heaters.
- (m) He must understand the construction and working of centrifugal, bucket, and plunger pumps, and the principles on which they act.
- (n) He must understand the construction and working of steering engines, electric light engines and dynamos, electric motors, refrigerating machinery, hydraulic machinery, and such internal combustion engines as are used to drive ships' launches, emergency and auxiliary machinery on board ship.
- (o) He must possess a creditable knowledge of the prominent facts relating to combustion, heat and steam.
- (p) He must be able to take off and calculate indicator diagrams and understand the distribution of the steam in the cylinder as shown thereby.
- (q) He must be able to make a dimensioned working sketch or drawing of some simple part of the machinery.

27. First-class Engineer. — A candidate for a first-class engineer's certificate must be not less than 22½ years of age.

A more extended knowledge of the subjects named in paragraph 26 will be required and in addition to the qualifications specified for a second-class engineer.

(a) He must :—

- (1) have served at sea for eighteen months, with a second-class certificate of competency or service, on regular watch on the main engines or boilers of a foreign-going steamship of not less than 99 nominal horse-power, as senior engineer in charge of the whole watch (*see* paragraph 41 of the Regulations); or
- (2) have served at sea for two years and three months, with a second-class certificate of competency or service, as first engineer of a home-trade steamer of not less than

- 99 nominal horse-power; or three years with a second-class certificate of competency or service as second engineer of a home-trade steamer of not less than 99 nominal horse-power; or
- (3) have served three years and nine months with a second-class certificate of competency or service as third or fourth engineer of a home-trade steamer of not less than 99 nominal horse-power, and during the entire period have been the senior engineer in charge of the whole of a watch on the main engines and boilers (*see* also paragraphs 47, 48, 49, and 50 of the Regulations; or
- (4) possess, or be entitled to, a first class certificate of service.
- (b) His knowledge of arithmetic must include the mensuration of superficies and solids and the extraction of square and cube roots, and the application of these rules to questions relating to the power, duty, and economy of engines and boilers, and to the stresses in rods, shafts, and levers of the engine. He should also be able to calculate the effect of the application of the lever, pulley, inclined plane, and other mechanical powers.
- (c) He will be required to make an intelligible hand sketch, or a working drawing, of one or more of the principal parts of a steam engine or boiler, and to mark upon it all the necessary dimensions in figures, so that the sketch or drawing could be worked from.*
- (d) He must be able to take off and calculate indicator diagrams, and to recognise and know how to correct defects in the distribution of the steam as shown thereby.
- (e) He must be able to calculate safety-valve pressures and the strength of the boiler shell and riveting, and of the furnaces, flat surfaces and stays.
- (f) He must be able to state the general proportions borne by the principal parts of the machinery to each other, and to calculate the direct stress, the torsional stress, and the bending stress in round bars, and the direct stress and the bending stress in rectangular bars with given loads.
- (g) He must be able to explain the method of testing and altering the setting of the slide valves, and to sketch approximately the difference any alteration in the slide valve will make in the indicator diagram.

* See Appendix D of the Regulations.

- (h) He must be conversant with surface condensation, super-heating, and the working of steam expansively.
- (i) He must understand the construction and working of, and be able to maintain in working condition the auxiliary machinery which is placed under his charge, viz.: refrigerating machinery, electric light engines and dynamos, electric motors, hydraulic machinery, the various descriptions of steering engines, and internal combustion engines as used in launches and for auxiliary and emergency machinery on board ship, &c.
- (j) He must know how to provide against defects and breakdowns of the machinery, and be able to direct and carry out any ordinary repairs that may be required either to the engines or the boilers.

28. First-class Certificates without Second.—The Board of Trade may see fit to allow an applicant who, in consequence of service abroad, has had no opportunity to obtain a second-class certificate, to be examined for a first-class certificate, although he does not possess a certificate of the lower grade, provided he is able to satisfy them as to the satisfactory character of his services, but these must be ample both as regards length and experience. As a rule, at least four years' sea service, a fair proportion of which must have been in a responsible capacity and qualifying for first class, will be required, but all applications under this paragraph should be submitted by the examiners to the Chief Examiner of Engineers for consideration.

If any such candidate fails to pass the examination for the first-class certificate, but passes that for the lower grade, he may be given a second-class certificate of competency, but no part of the fee will be returned. If he fails in practical knowledge, he may be re-examined for a second-class certificate only, subject to the usual regulations relating to such failures.

29. Extra First-class Engineer.—This examination is voluntary, and is intended for such persons as wish to prove their superior qualifications, and are desirous of having certificates for the highest grade granted by the Board of Trade.

30. Extra First-class Examinations when Held.—These examinations are held once in every three months, and at ports where examinations of engineers are ordinarily conducted. The examination extends over several days. According to present arrangements these examinations will begin on the second Tuesday in January, April, July, and October in each year.

31. Notice Required.—Notice must be given by the candidate at least one week before the day on which the examination begins, and these notices must be *immediately* reported by the examiners to the Chief Examiner in London.

32. Qualifications Required.—A candidate for an extra first-class engineer's certificate must possess a first-class engineer's certificate and have served an apprenticeship of five years at least, or, as an equivalent, three years' apprenticeship and three years at an approved technical school; or he must have served for one year at sea on regular watch on the main engines or boilers of a foreign-going steamship of not less than 66 nominal horse-power as senior engineer in charge of the whole of the watch while holding a first-class engineer's certificate.

In addition to the qualifications specified for first and second-class engineers:—

- (a) He must be able to write good English and have sufficient knowledge of elementary mathematics, trigonometry, etc.; to enable him to work problems in mechanical science.
- (b) He must possess a thorough knowledge of the construction and working of the different forms of marine engines and propellers in all their details, including turbines and the various types of internal combustion engines; must understand the fundamental principles on which they act; and be able to calculate the strength of the various parts.
- (c) He must be familiar with all the processes employed in the manufacture of machinery in an engineering workshop.
- (d) He must be acquainted with the general principles of theoretical and applied mechanics; must possess a knowledge of the theory of strain and stress; and be able to deduce the ordinary rules for the bending of beams and for the twisting and bending of shafts.
- (e) He must be acquainted with the modern theory of heat, and be able to solve questions relating to temperatures pressures and volumes, power, economy and duty in connexion with engines and boilers.
- (f) He must be able to determine, by means of valve diagrams or otherwise, the distribution of steam in the cylinders and the effect in a compound engine of alterations in any one cylinder on the steam pressures, power, etc., of the others.
- (g) He must understand how to apply the indicator, and be able to draw the proper conclusions from the diagrams, and to construct the approximate diagrams from any given data.

(h) He must be able to produce a fair working drawing of any part of the machinery, with figured dimensions fit to work from.

(i) He must understand the theoretical principles governing the action of the screw propeller and the paddle-wheel, and must be able to estimate numerically the effect in speed of ship and consumption of fuel due to any alteration in pitch, diameter, revolutions, etc.

(j) He must be able to give a description of boilers, including those of the water-tube type, and be familiar with the methods used in their manufacture, and must show that he possesses a knowledge of the theoretical principles which regulate their construction, and that he is able to calculate the strength of the various parts including the riveting, boiler shell, furnaces, flat plates, stays, etc.

(k) He must understand the general nature of the strains and stresses produced by steam pressure, temperature, etc., in the various parts of the engines and boilers.

(l) He must have a knowledge of the principles involved in determining the size of a safety valve, and in the construction of spring-loaded and deadweight valves.

(m) He must possess a thorough knowledge of the practice and theory of combustion; the chemical composition of fuels, coal, oil, etc.; the evaporative duty of fuels of given composition; the production of draught; the effect in regard to economy, safety, and wear and tear, of increasing or diminishing the proportion of heating surface, of grate bar surface, of area of section of air passages, of area of water surface, of steam space and water capacity.

(n) He must be able to explain the formation of scale and the precipitation of salt under various conditions, and the precautionary means adopted in respect thereto, with both jet and surface condensers.

(o) He must understand the general principles involved in the construction and working of the barometer, thermometer, salinometer, steam and vacuum gauges and other instruments used in the engine room, also of those used in determining high temperatures and in conducting experiments on heat.

(p) He must be familiar with the general results obtained from past experience in relation to corrosion, pitting, and

galvanic action in boilers, and the use of zinc and soda, and be able to explain the chemical reactions involved and know how to guard against deterioration of the boilers.

- (g) He must thoroughly understand the various causes and conditions which produce water-hammer action in steam pipes, the dangers occasioned thereby, and the precautions to be taken against them.
- (r) He must be able to give a variety of illustrations of how defects in the machinery have arisen from accident, imperfect construction, or deterioration, and to show how these defects might have been prevented, and the best way of repairing them.
- (s) He must be familiar with the properties and processes of manufacturing and testing the ordinary materials used in the construction of machinery, and must possess an intelligent knowledge of the composition and properties of the lubricants, boiler cements, india rubber, etc., in general use in steamers.
- (t) He must understand the causes of spontaneous combustion and the formation of explosive gases in coal holds, oil tanks, etc., and the precautionary measures proper to prevent accidents from these causes.
- (u) He must be acquainted with the fundamental principles and practice of the generation of electricity and its application to various purposes on board ship, and be able to describe and explain the working of the various machines, appliances, and instruments used.
- (v) He must be able to explain the construction and working of the refrigerating machinery in use on board ship, the electric lighting plant, the steering engines, hydraulic and pneumatic engines, the pumps, and all auxiliary machinery placed under the chief engineer's control, and also have a knowledge of the other machines and appliances usually found on board ship.
- (w) He must possess a knowledge of the stability of floating bodies, and of the laws which govern the rolling of ships, and be able to make calculations as to the effect of filling or emptying ballast tanks, working coal or cargo into or out of the vessel, moving of weights on board, etc.
- (x) He must possess a practical knowledge of ship construction and understand the elementary principles involved, and

be able to deal with engine and boiler seatings and to supervise and direct any repairs that may be required to an iron or steel ship.

If the candidate does not obtain 67 per cent. of the total number of marks allotted for the papers he will be declared to have failed. The papers will be founded chiefly on the foregoing sub-paragraphs.

33. Marine Technical Schools.—A candidate for either a second-class or a first-class certificate who, within two years from the date of application to be examined, has attended an approved course comprising general mathematical and scientific instruction at a technical school recognised by the Board of Trade as suitable for the training of *marine* engineers will be allowed to count time so spent as equivalent to sea service in the ratio of three months at the technical school to two months at sea. Time so spent cannot be accepted as equivalent to more than one-sixth of the total sea service required for either certificate, but a candidate who has been allowed to count such time on examination for a second-class certificate will not be debarred from counting similar subsequent time on examination for a first-class certificate.

Time spent in an approved marine technical school subsequent to obtaining a first-class certificate, and within two years from the date of application to be examined, may also be accepted as forming part of the qualifying service required under paragraph 32 of the Regulations in the case of candidates for extra first-class engineer's certificates, but if such time is substituted for sea service it will only count as equivalent thereto in the ratio of three months at the school to two months at sea.

In every case in which an allowance is made for time spent at a marine technical school, the candidate will be required to produce the principal's certificate for continuous and regular attendance at all the approved classes and for satisfactory progress.

Each candidate who claims remission of sea service on account of attendance at a recognised marine technical school must produce his class note books when he makes application to be examined.

These books will be forwarded to the Chief Examiner of Engineers, in order that he may satisfy himself that the candidate has followed the approved course of instruction, and that the remission of sea service claimed may be allowed accordingly.

Application for examination of candidates claiming remission of sea service should, as a rule, be made at least a week before they desire to sit.

A list of the marine technical schools recognised for this purpose is given in Appendix K.

Sea Service.—It is desirable that the whole of the candidate's sea service should be covered by testimonials certifying to his sobriety, experience, ability, and general good conduct, but in future the usual testimonials will be required for at least the last 18 months at sea preceding the date of the application to be examined.

All candidates, including those for first class who have not been in charge of the whole of a watch but qualify under paragraph 41 of the Regulations as the second or third senior of the watch and have been in charge of a section of the machinery only, will be required to have served at sea on regular watch on both the main engines and the boilers, not less than six months being spent on each.

The service described in paragraphs 47, 48, 49, and 50 of the Regulations may as heretofore be accepted as qualifying for examination in accordance with the conditions specified in those paragraphs.

Certificates for Engineers of Home-trade Passenger Ships propelled by Oil Engines.

34. Oil Engine Certificates.—Candidates may be examined for second-class certificates of competency as engineer of vessels propelled by oil engines.

These certificates will entitle the holders to go to sea as second-class engineers of home-trade passenger ships propelled by oil engines, but will not entitle them to go to sea as second-class engineers of foreign-going ships or of home-trade passenger steamships.

35. Second-class Engineer (Oil Engines).—A candidate for a second-class oil engine certificate must be at least 21 years of age.

(a) He must prove:—

(1) Four years' experience at the making or repairing of machinery, of which at least six months must be at the making or repairing of oil engines, or

(2) Three and a half years' experience in charge of engines and boilers at sea or an equivalent suitable experience on shore,

and, in addition to either (1) or (2):—

(3) Six months' experience with oil engines at sea.

NOTE.—Alternative service to the above may be considered but it is essential that the candidate should have experience with oil engines, and have spent at least six months at sea in the engine-room of a sea-going vessel.

(b) He must write a legible hand, and have a good knowledge of

arithmetic up to and including vulgar and decimal fractions and square root. He must also understand the application of these and other rules to problems relating to spring and lever-loaded relief valves, and be able to solve questions about the relative speeds of a vessel at different revolutions, the capacity of oil tanks, etc.

- (c) He must be able to give a clear explanation of the principle on which an oil engine works, and to show by means of illustrative sketches and otherwise that he understands the construction of those in general use.
- (d) He must be able to describe the chief causes which may make the engine difficult to start, and to explain how he would proceed to remedy any defects.
- (e) He must be able to show that he understands the mechanism of the starting and reversing arrangement, and is competent to deal with defects which may lead to failure in the prompt handling or reversing of the engine.
- (f) He must have sufficient mechanical ability to be able to overhaul the engine, to adjust the working parts, and to put the engine together again in good working condition.
- (g) He must be able to give satisfactory answers to the elementary questions numbered 305 to 310 inclusive. (*See pp. 237 to 251 of this book.*)
- (h) He must be able to prove (by actual trial if practicable) that he is competent to manipulate an oil engine when under way by starting, running the engine, stopping, reversing or slowing down.
- (i) He must understand what is meant by the flash point, and have a knowledge of the explosive properties of the oil generally used in oil engines when exposed in the open air, and the danger of exposing any vapour from the oil to a light or of allowing any leak from the oil tanks, particularly into the vessel's bilges.
- (j) He must understand the action of wire gauze diaphragms when placed in pipes and connections to oil tanks, etc., for the purpose of preventing the explosion or ignition of oil vapour therein.
- (k) He must be able to take the necessary precautions to guard against the escape of inflammable vapour from the vaporiser when the engines are stopped.
- (l) He must be able to explain the principle and construction

of a dynamo and the construction and arrangement of primary and secondary batteries and induction coils, so far as is necessary for the efficient management of an oil engine.

36. Workshop Service.—Workshop service must have been performed in works where steam engines, boilers, etc., are made or repaired, but no time served before the age of 15 will be counted.

Not less than two years of the apprentice time must have been spent at fitting, erecting, or repairing engines and machinery either in the works or outside. The remaining two years may be made up of time spent in engine works at fitting, erecting, or repairing engines and machinery or at one of the other branches of the trade given below, or at an approved technical day school (*see* Appendix K); the time so spent to count as follows:—

Fitting, erecting, repairing or turning		Full time.
Working in drawing office		Full time up to one year, and beyond one year one-half time.
Patternmaking		One-half time with a maximum allowance of one year.
Planing, slotting, shaping, and milling		One-third time.
Boiler-making or repairing		One-half time.
Smith work		One-half time with a maximum allowance of one year.
Coppersmith work		One-third time with a maximum allowance of six months.

In the event of the apprentice time being extended to five years or more, four years at turning *followed* by one year at fitting or erecting may be accepted as qualifying.

This paragraph applies only to works at which the making and/or repairing of steam engines, boilers, etc., forms part of the regular business for which the works exist. Service at works where the repairing of steam engines, boilers, etc., is merely incidental to the running of plant, however large, which is used for the production of power for other machinery, etc., should be dealt with under paragraph 38, each case being considered on its merits.

37. Workshop Service other than the above.—When the workshop service has been performed in a place where engines are made, but not in the manner specified in paragraph 36, the case must be referred to the Board of Trade with a report upon the service

performed. If the service be such as is useful training for an engineer, the Board may accept the service; but in every such case the applicant must prove additional engine room or marine engine workshop service as required in the succeeding paragraph.

38. Workshop Service where Engines are not made.—

When the workshop service has been performed in a place where steam engines are not made or repaired, and the class of work done is similar to that required in engine making, the service may be accepted with an additional year of qualifying service; that is, four years' workshop service and either two years at sea on regular watch, or one year at engine fitting in a suitable marine engine workshop and one year at sea in the engine room. The approval of the Board of Trade must be obtained in every such case before the candidate is examined.

Service in Colonial and Foreign Workshops.—Paragraphs 36 to 38 apply to service in the United Kingdom only. Service in a Colonial or foreign workshop will not be accepted unless the examiner is satisfied in each case that its value is substantially equivalent to that of service performed in the United Kingdom. In cases where the examiner is not satisfied that the value is equivalent, he will refer to the Chief Examiner of Engineers.

Workshop service in India is in no case to be taken as equivalent to more than four-fifths of the same period of service in the United Kingdom.

39. Technical Schools.—Time spent after the age of 15 at a technical day school (recognised by the Board of Trade as suitable) where there is an engineering laboratory, may be taken into account and accepted as equivalent to artisan service, usually at the ratio of three years in the technical school to two in artisan service, provided that the applicant has taken the full engineering course and can produce the principal's certificate for regular attendance at all the approved classes and for satisfactory progress; and provided also that the remaining portion of the time has been spent in works where steam engines, boilers, etc., are made or repaired, in accordance with the scale of values indicated above.

Time spent in attending evening classes in engineering at approved technical schools will similarly be allowed to count under the following conditions:—

- (1) Each candidate claiming an allowance for time spent in attending evening classes at a technical school must produce a certificate signed by the principal of the school to the effect that he has attended regularly at a definite class

or classes, which should be specified, and has made satisfactory progress. This certificate must also state the total number of hours spent by the candidate in attending each class.

- (2) Time spent by the candidate in attending such classes as have a direct bearing on the training of a marine engineer will be reckoned at the rate of five hours to one day. The total number of days so obtained will then be accepted in lieu of a certain fraction of the same period of workshop service. This fraction will be fixed for each school at the time of approval, and will generally be two-thirds.
- (3) A candidate who has attended a technical school in the evening, while being employed as an apprentice or journeyman engineer during the day, must, in order that the school time may be accepted, produce satisfactory proof that he has spent the full working day in the works, at which he is employed, before attending the school. Such proof will usually take the form of a statement in the testimonial as to workshop service given by the employer.
- (4) Allowance will only be given for classes attended after the candidate has reached the age of 15.

For list of approved technical schools and time allowed for attendance at each, see Appendix K.

40. **Sea Service.**—The sea service required by these Regulations is, unless otherwise stated, service performed in foreign-going ships of at least the nominal horse-power specified for the respective grades of certificate. The nominal horse-power, as given on the vessel's certificate of registry, may in all cases be accepted by the examiners.

41. **Qualifying Service defined.**—In the case of candidates for first-class certificates, qualifying service means, as a rule, service on regular watch on the main engines or boilers as senior engineer in charge of the whole watch. When, however, three or four engineers are on watch at the same time the service of the two seniors may be allowed to count, and when not less than six engineers are on watch together that of the three seniors, provided a certificate from the superintending engineer is produced stating the number of engineers on watch, the rank held by the applicant and that he was in full charge of a watch on a definite section of the main engines or boilers. During the whole of the period claimed, candidates must have been in possession of second-class certificates.

In the case of candidates for second-class certificates qualifying

service means service as engineer on regular watch on the main engines or boilers. In no case will time spent in clerical work be allowed to count.

42. Further as to Qualifying Service.—Only such service as gives the experience required to make a man thoroughly competent as a sea-going engineer is accepted as qualifying service. Even for a second-class certificate the candidate must prove to the satisfaction of the examiner that he is qualified by experience and knowledge to act as chief engineer in an under-powered steamer of 99 nominal horse-power on a voyage, say, from England to Egypt, taking full responsibility for engines and boiler.

43. Foreign Engineers.—Foreign engineers cannot be examined for a first-class or extra first-class certificate unless they have performed the sea service stated in paragraphs 27 and 32 respectively, with the requisite British certificate. The service may have been performed in foreign vessels if the candidate can produce satisfactory testimonials as to conduct and character, and is able to prove that the service has been in the required capacities, and that during the period of service he has held a British certificate of competency of the rank required by the Regulations (*see* paragraph 16).

44. Names on Articles.—In all cases the candidates' names must have been duly entered on the ship's articles as engineers in their proper ratings.

45. Regular Watch.—Being on regular watch means being on watch for at least eight hours a day.

46. Home-trade Service.—Service in the home or coasting trade is regarded as being equivalent to two-thirds of the same period of time served in the foreign trade except where other allowances are specified. *See* paragraphs 27 (a) (2) and (3), 47, 49, and 50.

47. Lake or River Service.—Service as watch-keeper on a lake or river steamer of not less than 66 nominal horse-power may be accepted under the following conditions:—

- (a) the service will only count half as much as sea service; *i.e.*, every two months of lake or river service is only equivalent to one month's foreign-going sea service;
- (b) candidates for second-class certificates must prove, in addition to the lake or river service, at least three months' qualifying service at sea in a foreign-going steamship of not less than 66 nominal horse-power, or four and a half months' similar service in the home trade;
- (c) candidates for first-class certificates must prove, in addition to

lake or river service in vessels of not less than 99 nominal horse-power, at least six months' qualifying service at sea, with a second-class engineer's certificate, in foreign-going vessels of not less than 99 nominal horse-power or nine months' similar service in the home trade.

48. Service in Auxiliary Screw Steamships.—Service performed on board auxiliary screw whalers and other vessels with auxiliary steam power of not less than 66 nominal horse-power, in the capacity of engineer may be allowed to count towards qualifying candidates for examination for second-class engineers' certificates of competency to the extent of one-half the time the vessel is actually at sea. If the candidate is able to prove a larger amount of time under steam, he will be allowed to count the whole of such extended time.

49. Service in Dredgers, Fishing Boats, Tug Boats, or Pilot Vessels.—Service in sea-going steam dredgers, fishing boats, or tug boats, and in sea-going pilot vessels when on their station or when going to or returning from the same, may be accepted under the following conditions:—Two months of such service is only equivalent to one month's qualifying service in a foreign-going steamer. Candidates for second-class certificates may perform all their sea service in sea-going steam dredgers, fishing boats, tug boats, or pilot vessels, but they must have been on regular watch on the main engines or boilers, and the vessels must not be less than 66 nominal horse-power. Candidates for first-class certificates must while in possession of a second class certificate have served in vessels of at least 99 nominal horse-power, and have been in charge of a watch on the main engines or boilers. They must, in addition, have served in a qualifying capacity for at least six months in a foreign-going cargo or passenger steamship, or nine months in a home-trade cargo or passenger steamship.

Where an engineer is employed on a fishing or other vessel and is required to do stoking or other work not usually performed by an engineer in the Mercantile Marine, such service cannot be accepted as qualifying.

The examiners of engineers will in all cases satisfy themselves that service on fishing boats, when claimed as qualifying for a certificate as engineer, is of a similar nature to that performed by engineers in the Mercantile Marine

50. Service in Yachts.—Service performed in steam yachts, either within or beyond home-trade limits, may be accepted as equivalent to two-thirds of the time performed in foreign-going trading vessels, provided that the candidate's name is entered on the vessel's

articles, and that he can prove, to the satisfaction of the examiner, that the time claimed was actually served at sea.

Candidates for second-class certificates may perform all their service in yachts, but the candidate must have been on regular watch on the main engines or boilers, and the vessel must be of not less than 66 nominal horse-power.

Candidates for first-class certificates must have served on vessels of not less than 99 nominal horse-power, and must have been in regular charge of the main engines or boilers. In addition they must have served for at least three months in a qualifying capacity on board a foreign-going cargo or passenger steamship. This additional service will, however, not be required in the case of a candidate who has served for eighteen months as first engineer, or for two years as second engineer, of a steam yacht of the requisite power.

51. Certificates of Service.—An officer who has attained the rank of engineer lieutenant or engineer sub-lieutenant in His Majesty's Navy or the rank of engineer or assistant engineer in the Indian Marine Service is entitled without examination, if an engineer lieutenant or engineer, to a certificate of service as first-class engineer, and, if an engineer sub-lieutenant or assistant engineer, to a certificate of service as second-class engineer. These officers may be examined for a certificate of competency on the same conditions as engineers of the Mercantile Marine.

An officer who has attained the rank of chief artificer engineer in His Majesty's Navy is also entitled without examination to a certificate of service as second-class engineer.

52. Examination of Engine Room Artificers.—Artificer engineers, chief engine room artificers, engine room artificers, and mechanics in the Royal Navy may be examined for certificates of competency on the same conditions as engineers of the Mercantile Marine.

53. Application by Naval Officers.—The Lords Commissioners of the Admiralty have directed that applications from officers, of the Navy for certificates of service or for permission to be examined for certificates of competency must, in the case of officers on the active list, be made through the commanding officer to the Secretary to the Admiralty, and in the case of officers who are on half pay or who have retired, direct to the Secretary to the Admiralty, who in either case will forward the applications to the Board of Trade.

It is not necessary for applications of chief engine room artificers and mechanics, who have left the Royal Navy and who desire to be

examined for certificates of competency as engineers in the Mercantile Marine, to be forwarded either through their commanding officers or through the Admiralty. Men who are still serving in these ratings in the Royal Navy should make their applications through their commanding officers.

Artificer engineers, however, being warrant officers, should make their applications in the same manner as that laid down for other officers of the Royal Navy.

54. Masters' and Mates' Examination in Steam.—Particulars of the examination of masters and mates in steam will be found in Appendix G of these Regulations.

55. Certificates.—The term "certificate" in these Regulations means a certificate issued by the Board of Trade, or by a British Possession under Order in Council in accordance with sec. 102 of the Merchant Shipping Act, 1894. A list of the Colonial certificates issued under Order in Council is given in Appendix H; and the holder of a certificate so issued must not be examined in the United Kingdom for a certificate of the grade already held.

56. Colonial Local Certificates.—The holder of a Colonial certificate of competency not granted under the Merchant Shipping Act, or of a certificate of competency granted after examination on board one of His Majesty's ships, who wishes to be examined for a Board of Trade certificate of the same grade, must prove that he has performed the amount of service required by these Regulations for that grade, and complied with the conditions laid down as to testimonials. No fee will be demanded for the first attempt, but if the candidate fails the usual fee will be demanded on any subsequent attempt.

All Colonial certificates for marine purposes, whether local or issued under Order in Council, must be given up before a further certificate is issued by the Board of Trade.

CHAPTER III.

CONDUCT OF THE EXAMINATIONS.

57. Commencement and Duration of Examinations.—The examinations will, as a rule, commence at 10 a.m., and will be continued from day to day until all the candidates whose names appear upon the superintendent's list on the day of examination are examined.

58. Candidates to be Punctual.—Candidates are required to appear at the examination room punctually at the time appointed.

59. Tables to be Cleared.—Before commencing the examination the tables and desks must be cleared of all scraps of paper, or books that are not used in the examination, and care should be taken that the candidates while in the examination room do not have in their possession any book or paper, except as specified in paragraph 64.

60. Strangers not Admitted.—No persons will be allowed in the rooms during the examinations other than those whose duties require them to be present.

No instructors will be allowed on the premises.

61. Face Sheet and Blotting Paper.—At the commencement of the examination a face sheet should be given to each of the candidates, and they should be instructed to read the rules contained therein. A sheet of blotting paper will be issued to each candidate with the first examination paper, and it must be returned to the examiner when the last paper is completed each day. The examiner will be careful to see that the blotting paper has not been used by the candidate in solving his problems or for conveying information to other candidates.

62. All Work to be Shown.—No candidate will be allowed to work out his problems on a slate or on waste paper, or to write on the blotting paper supplied for his use in the examination. Violation of this rule will subject the candidate to all the penalties of failure.

All worked papers must be signed and dated and the name of the port of examination inserted by the candidate.

Additional sheets of paper will be supplied by the examiner if required, but they must be attached to, and form part of, the examination papers.

63. Books and Papers Strictly Forbidden.—All books necessary for the use of candidates under examination will be provided by the Board of Trade, and candidates are prohibited from bringing into the examination room books or papers of any kind whatever, except as specified in paragraph 64. The slightest infringement of this regulation will subject the offender to all the penalties of failure, and he will not be allowed to present himself for re-examination for a period of three months or, if a candidate for an extra first-class certificate, for a period of six months.

64. Book of Logarithms.—Candidates for examination for extra first-class certificates may use the examination room book of logarithms, which must be always kept under the charge of the examiner, who will be careful to observe that it is not used to conceal memoranda prepared for these examinations. No other books will be allowed unless the question set specially states that a book may be referred to.

Candidates for extra first-class certificates may, however, be allowed to use their own tables of four-figure logarithms if they so desire.

In allowing the use of such tables, examiners should be particularly careful to see that they contain no notes, formulæ, or other information either printed or written, apart from the actual tables of logarithms and trigonometrical ratios; and before the commencement of the examination any tables which the candidates propose to use should be examined to see that no matter is contained in them.

65. Drawing Instruments.—Candidates for first-class certificates have to pass an examination in rough working drawing, which may, in the candidate's option, be either hand sketches clearly dimensioned and complete in the necessary views and sections, or drawings to a scale. Drawing boards and T squares will be provided by the Board of Trade, but the applicants will have to bring with them any drawing instruments they may require.

66. Candidates' Places.—Candidates should be so placed as to prevent one copying from another, and no communication whatever between the candidates should be allowed.

67. Penalty for Copying, etc.—In the event of any candidate being discovered referring to any book or paper, or copying from another, or affording any assistance or giving information to another, or communicating in any way with another, during the time of examination, or copying any part of the problems for the purpose of taking them out of the examination rooms, he will subject himself to all the penalties of failure, and will not be allowed to be again examined for a period of six months, or, if a candidate for an extra first-class certificate, for twelve months.

68. Leaving Room or Building.—No candidate may leave the examination room without permission and without giving up the paper on which he is engaged. Under no circumstances will the same paper be returned to him, but the examiner may substitute other data, or another question.

69. Injury to Books.—If a candidate defaces, blots, writes in, or otherwise injures any book or form belonging to the Board, his papers will be retained until he has replaced the damaged book or document. He will not be allowed to remove the damaged book or document, and will be subjected to all the penalties of failure.

70. Silence.—Perfect silence is to be preserved in the examination room.

71. Penalty for Breach of Rules.—Any candidate violating any of the regulations, or being guilty of insolence to the examiner, or of disorderly or improper conduct in or about the room, will render himself liable to the postponement of his examination, or, in the event of his having passed, to the detention of his certificate for such period as the Board of Trade may direct.

72. Order of Examinations.—The examination of candidates for second-class certificates consists of three parts: arithmetic, elementary questions, and *viva voce*; and that of candidates for first-class certificates of four parts: arithmetic, drawing, elementary questions, and *viva voce*. See paragraphs 26 and 27.

73. Examination Papers, when to be Opened.—The arithmetical questions for each examination will be sent from the office of the Chief Examiner of Engineers in London, and should, when worked, be returned to him for marks to be assigned; one sheet only at a time should be given to the candidate and not more than two hours should be allowed for any one sheet. Envelopes containing examination papers are on no account to be opened by any other person than the examiner, and by him only at the commencement of the examination. He should see that the packet has not been tampered with and he is expected to take special precautions to preclude the possibility of any unauthorised person having access to them. All unworked sheets should be returned to the Chief Examiner at the conclusion of each day's work.

74. Arithmetic.—When the number of marks obtained in arithmetic amounts to 28, that is, two-thirds of the maximum, the candidate passes in arithmetic.

If the marks obtained amount to 21, but not to 28, and if the applicant has had long experience, his testimonials and service should

be taken into account, and his examination continued, if deemed advisable by the examiner, and he may be passed or failed, having due regard to his practical knowledge, and to whether he is being examined for second class or first class.

75. Drawing.—With regard to a candidate's drawing, when the word "consider" is telegraphed instead of either of the words "fail" or "pass" it must be understood to mean that the examination may be proceeded with so far as the drawing is concerned, and the candidate passed if in the remaining part of it he shows a superiority in practical knowledge.

76. Elementary Questions.—All engineer applicants presenting themselves for examination will be required to give written answers to ten questions selected from elementary questions shown by Nos. 1 to 310. (*Note by Author.*—The candidate should here read paragraph Elementary Questions below.) These questions are intended to furnish a record to some extent of the candidate's knowledge at the time of his examination, and also to induce the candidates to pay more attention to their handwriting and spelling.

Examiners will require all candidates to fill up a form Exn. 156, and they will forward it to the Chief Examiner of Engineers with the report of the examination.

The elementary questions will, as a rule, be given on the second day of the examination to candidates for second class, and on either the second or third day to candidates for first class, but candidates who have time after working the arithmetical papers on the first day or the drawing on the second day may be allowed to go on with the elementary questions.

The questions for both classes of engineers will be taken from the same series of elementary questions; and candidates for first-class certificates are expected to show their superiority by giving answers more complete than those of the other candidates.

Elementary Questions.—In future, the elementary questions, referred to in paragraph 76 above, will not necessarily be taken from Nos. 1-310, but may be new questions somewhat similar in form and covering much the same ground.

77. Viva Voce.—Having regard to the fact that when the verbal examination is held the candidate has already passed in arithmetic and, if a first-class candidate, in drawing, and has also written answers to the elementary questions, the examiners should deal with practical rather than theoretical questions in this division of the examination; and no candidate should be failed in the verbal examination without having been well cross questioned on the points for which failure takes

place. Candidates may, however, be failed in the written elementary paper without being examined *viva voce*. In cases where the examiner approves of the elementary paper, but fails the candidate for lack of either practical or elementary knowledge, a written account of the points on which he failed must be forwarded to the Chief Examiner of Engineers with the elementary papers and the report Exn. 15.

The elementary questions to be answered on form Exn. 15b are good starting points in *viva voce* examinations. With the candidate's written answers before the examiner the same question can be put in a way requiring the answer in another form. Each question may be developed into several according to the circumstances of the case, e.g.:—

1. What is made of? Of what parts does it consist?
2. What is its use?
3. What attention does it require at sea?
4. What attention does it require in port?
5. When it becomes defective, what is it that principally goes wrong with it?
6. How is it repaired?
7. What alteration may prevent a recurrence of the defect?

It is considered of great importance that engineers presenting themselves for examination should have an extensive knowledge of the particulars of actual casualties which have occurred at sea, and be able to state how these might have been prevented, and how remedied. Sometimes an engineer presents himself who has had no personal experience of any defects, and who can tell nothing about casualties to machinery which have occurred in the experience of others; such candidates should be closely questioned as to their knowledge of boiler and engine construction and the repairs of same.

The management of engines and boilers at sea, the duties of the engineer on watch, the work to be done to the engines, boilers, and auxiliary machinery in port, and the periodical examinations of the working parts, should form part of the *viva voce* examination.

78. Reports of Examinations.—Reports of examinations on the form Exn. 15, together with the examination papers, forms Exn. 37 and face sheets, should be forwarded to the Chief Examiner of Engineers, 79 Mark Lane, London, E.C., immediately the examinations are completed, and the candidate's application to be examined (form Exn. 3) duly filled up, together with his previous certificate, if any, should be sent to the Registrar-General of Seamen; his discharges and testimonials should be returned to the candidate.

APPENDICES.

APPENDIX A.

EXAMINATION DAYS AT

Place.	Days.
Aberdeen	3rd Tuesday in each month.
Barrow in Furness	2nd Tuesday in each month.
Belfast	4th Tuesday in each month.
Bristol	3rd Tuesday in each month.
Cardiff	2nd and 4th Tuesdays in each month.
Cork	2nd Tuesday in each month.
Dover	3rd Tuesday in each month.
Dublin	1st Tuesday in each month.
Dundee	1st Tuesday in each month.
Falmouth	4th Tuesday in each month.
Glasgow	2nd, 4th, and 5th Tuesdays in each month.
Greenock	1st and 3rd Tuesdays in each month.
Hartlepool, West	2nd Tuesday in each month.
Hull	1st and 3rd Tuesdays in each month.
Leith	2nd and 4th Tuesdays in each month.
Liverpool	Tuesday in each week.
London	Tuesday in each week.
Londonderry	3rd Tuesday in each month.
Middlesborough	4th Tuesday in each month.
Plymouth	2nd Tuesday in each month.
Shields, North	Tuesday in each week.
Southampton	2nd and 4th Tuesdays in each month.
Sunderland	3rd Tuesday in each month.

N.B.—The examination days are liable to occasional alteration.

EXTRA CERTIFICATES.

According to present arrangements the Examinations for Extra Certificates will begin at the different ports on the
Second Tuesday of January in each year.

"	"	April	"
"	"	July.	"
"	"	October	"

APPENDIX B.

Form to be filled up by all Candidates at the examination.

Form Exn. 15b.

Port	Class for which examined
Date	Candidate's Name

- A. Where and how long did you serve in works at the making or repairing of engines and boilers?
- B. How long and in what capacity did you serve in works on shore other than at the making or repairing of engines and boilers?
- C. How long have you served in the engine-room at sea, and in what capacities?
- D. With what descriptions of engines have you served at sea? What sizes were the engines?
- E. With what descriptions of boilers have you served at sea?
- F. What engine defects, or defects to auxiliary machinery, have come under your notice, what caused these defects, and how were they remedied? Give the names of the steamers for verification.
- G. What boiler defects have come under your notice, what caused these defects, and how were they remedied? Give the names of the steamers for verification.

APPENDIX D.

EXAMINATION IN ROUGH WORKING DRAWING FOR A FIRST-CLASS ENGINEER'S CERTIFICATE OF COMPETENCY.

Form Exn. 17.

1. The regulations of the Board of Trade in regard to the qualifications of a candidate for a first-class engineer's certificate of competency specify that,—

“He will be required to make an intelligible hand sketch, or a working drawing of some one or more of the principal parts of a steam engine, and to mark in, without a copy, all the necessary dimensions in figures, so that the sketch or drawing could be worked from.”

“He must be able to state the general proportions borne by the principal parts of the machinery to each other.”

2. In accordance with these clauses, a candidate for a first-class certificate is required to make a rough working drawing of the parts specified as on page 285. An engineer who has been some years in charge of marine engines and boilers ought to have familiarly in his mind the general construction of at least one set of engines and boilers, say that set he was last with. Fine drawing is not expected, and in the proportions of the parts a wide margin will be allowed; absurd dimensions will entail failure in practical knowledge.

3. The drawing must, however, be practically a working drawing, giving a sufficient number of views to show the parts fully—sections, plans, or elevations, just as the candidate would require to be supplied to him if he had to make the parts represented to the design of another person.

4. A clear hand sketch showing the construction completely, and fully dimensioned, will be accepted if the candidate prefers this alternative.

5. A portion only of the parts specified may be accepted in place of the whole, if that portion is sufficient to show that the candidate has a good practical idea of the construction of the parts, and a fair notion of their general proportions or dimensions.

6. Candidates are cautioned not to put on paper what they have not fully considered, and deliberately intend to be understood, as

evidence of what they know about the construction of any part required.

7. The statements given in by a candidate may be in themselves, apparently, of little importance, but, as sample material from which the extent of the candidate's knowledge of engines and boilers is to be inferred, every detail which is glaringly inconsistent with a sound knowledge of the use of the part, or in which an essential consideration has evidently been overlooked, is an important element in the description which the candidate is giving of his own qualifications.

8. The candidate is advised not to begin more than he can clearly finish in the time allowed. An important object in this part of the examination is to ascertain whether the candidate can be trusted to mark all necessary dimensions upon a sketch or a drawing. The test of this is, practically, the making of the part from the sketch without having to supply additional dimensions, and without measuring the drawing. To prove this ability the candidate must fully dimension the parts shown in his sketch or drawing, notwithstanding that the parts may be correctly drawn to scale. A drawing is fully dimensioned when no part of it is left to the option of the party who is to work to the drawing.

9. To prevent misunderstanding, however, when the candidate has been led into showing more of the details than he has time fully to finish, he should name, in the statement on the other side, the particular parts which he has not fully dimensioned.

10. All dimensions should have lines and darts to indicate distinctly the points between which the dimensions are given.

11. Beware of writing cross dimensions upon centre lines, or upon longitudinal dimension lines. This is not an order but a recommendation.

12. The candidate is not expected to design anything; he has merely to sketch or draw something with which he is expected to be already familiar. At the same time, he should call attention to any defect in the design of the article or apparatus. Omission to do so will imply want of practical knowledge.

13. Pencil in nothing after half past 3; all the dimensions, the figures, and the darts must be inked in; employ the remaining time in examining the drawing and in inking in any figures which may have been before overlooked, and in checking the dimensions.

14. Make sure that you will have sufficient room on the drawing sheet to show all the necessary views. You can have another sheet of drawing paper if necessary. All the paper used must be forwarded with the drawing.

SUBJECT FOR EXAMINATION IN ROUGH WORKING DRAWING.

Form Exn. 17a.

(Specimen.)

Read the Foregoing General Instructions.

A common slide valve with its spindle. Show also an outline section of the ports at the cylinder face. Show the provision for connecting the slide valve to the spindle.

The candidate is requested to fill up the following, and to attach this paper to his drawing.

STATEMENT BY THE CANDIDATE.

The accompanying drawing, made by me this day, without referring to any document, and without the assistance of any person, is intended by me to be sufficient for the new construction of the parts above described to fit the places of similar parts which are to be removed. The construction is similar to what I have been with in the..... steamer....., but the dimensions may be different.*

The diameter of the cylinder is.....

The stroke of the piston is.....

The travel of the valve is.....

The cover at top end on steam side is.....

The cover at bottom end on steam side is.....

The lead at top is intended to be.....

The lead at bottom is intended to be.....

The inside cover is + ... or -

The thickness of the face of valve is.....

The thickness of the body of valve is.....

The greatest opening for steam will be.....

That gives an area equal to one.....th of the piston.

The opening for exhaust when the crank is on the top centre is.....

That gives an area equal to.....th of piston.

{ The length of the connecting rod is.....

† The valve will cut off steam on the down stroke at.....

{ The valve will cut off steam on the up stroke at.....

It is required that all the parts shall be fully dimensioned in ink, but if, owing to want of time, this has not been done, the parts not fully dimensioned must be stated, otherwise it will be understood that the candidate considers the dimensions given sufficient.

The parts not fully dimensioned are.....

Dated at.....

this.....day of.....19...

.....Candidate.

* Run the pen through the words that do not apply.

† The candidate may omit this part if he chooses.

APPENDIX E.

READING THE WATER-GAUGES.

Notwithstanding that the reading of the water-gauge is made a special feature in the examination of engineers, many boiler casualties result from the engineer of the watch either not understanding the construction of the water-gauge fittings or not satisfying himself by actual trial that the cocks, pipes, &c., are clear.

In one case, two furnace crowns came down in a steamer that was just starting on a voyage. The engineers were satisfied that there was plenty of water in the boiler because the water-gauge showed full glass, and they called the attention of a Board of Trade Surveyor to this fact as being conclusive evidence that the casualty could not have resulted from shortness of water. On examination of the fittings, however, it was found that the cock between the boiler and the steam pipe leading to the gauge was shut, having been carelessly left in that position on the previous day when the mountings were overhauled for survey. Directly the cock was opened the water disappeared from the gauge glass, and the second engineer admitted that he had blown down the boiler in order to lower the water level, as the glass was full.

Many steamers have had their furnaces brought down at sea in a similar manner to the above through what the engineers of the watch have called "false water in the glass," and which on examination has been found to result from the top communication being choked.

These casualties resulted from what, to say the least, was bad management, not false water.

Unless a candidate under examination is able to prove that he understands how to verify the indications of the water-gauge, he should not be passed in practical knowledge, and, as failure in practical knowledge involves the candidate going to sea for another three months before being eligible for re-examination, the examiner should explain to such candidate his error, after failing him, in order to prevent further casualties resulting from his want of knowledge on this subject.

The sketch, figures 1, 2, 3, 4 and 5 (page 289) represent the usual methods of attaching water-gauge mountings to marine boilers. The important features in each gauge and the method of verifying its indications are dealt with separately in the following remarks.

REFERRING TO FIGURE 1 ONLY.

In this case the water-gauge cocks are attached direct to the boiler, and the accuracy of the gauge when the boiler is under steam can be tested as follows:—

First.—Let *B* remain open, then close cock *D* and open cock *E*, and if steam issues it proves that cock *B* and the passage through the top fitting and gauge glass are clear. If no steam or water issues, either cock *B* or the passage through the top fitting and gauge glass is choked and the gauge cannot act properly until the obstruction is removed.

Second.—Close cock *B* and open *D* and *E*, and if water issues, cock *D* is clear. If no water or steam issues, either cock *D* or the passage from the boiler through the lower fitting is choked and must be cleared before the gauge can act properly.

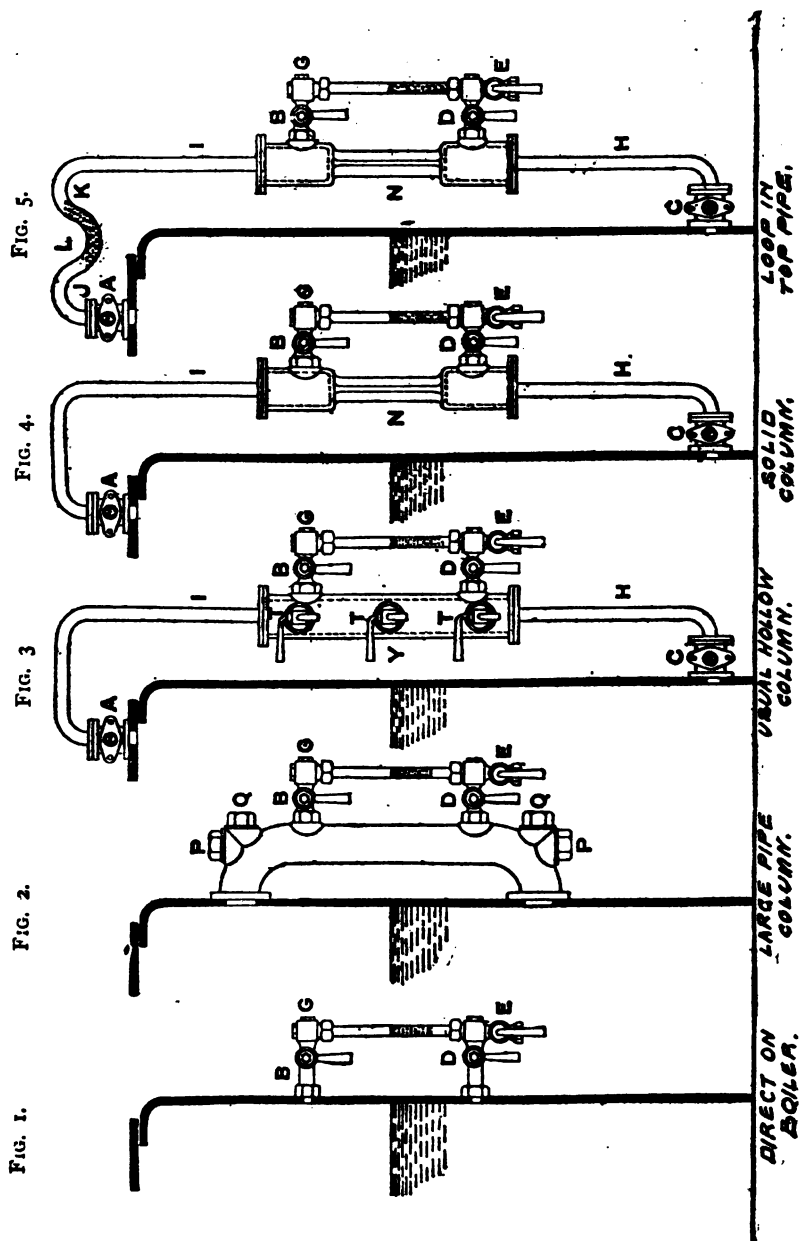
REFERRING TO FIGURE 2 ONLY.

In this case the gauge cocks are attached to a bent pipe of comparatively large diameter (at least 3 inches in the bore), the upper end of which communicates with the steam space, and the lower end with the water space of the boiler. Owing to the bore of the pipe being large it is not liable to become choked or stopped under the ordinary conditions of working. The water-gauge is, therefore, in practically the same condition as if it were attached direct to the boiler, as in figure 1. This gauge, when at work, is tested in precisely the same manner as the one shown in figure 1.

Screw plugs are inserted at *PP* and *QQ*, by the removal of which the apertures in the pipe can be cleared, if necessary, by the insertion of a wire or rod when steam is down.

REFERRING TO FIGURE 3 ONLY.

In this gauge there is an open communication from *A* to *C* through the column *Y*, and in order to "blow through the glass" it is only necessary to shut cocks *D* and *B* alternately, keeping *E* open. But to "blow through the water-gauge," including the pipes *H* and *I*, it is necessary, after blowing through the glass as described above, to shut *A* and *C* alternately, at the same time keeping *B*, *D* and *E* open for such time as will ensure the complete discharge of the contents of the gauge and its connections. When *B*, *D* and *C* are clear and *A* choked, the steam lodging in the glass and in the pipe *I* leading from column *Y* to *A* becomes condensed and the water flowing through *C*



to take its place rises in column *Y* and in the glass to a level above that of the water in the boiler. In other words, the gauge shows a false level. If now *E* be opened and water is blown out, then on *E* being again closed the water in the gauge will rise higher than before and be still further misleading. On the other hand, when *B*, *D*, and *A* are clear and *C* choked, the water, if any, in the glass is trapped and no longer rises and falls with the water in the boiler or with the motion of the vessel; it, however, slowly rises in the glass owing to the condensation of the steam in the upper part of the gauge until such time as *E* is opened, when the whole of the water in the glass is blown out, and on *E* being closed the glass does not show any water, notwithstanding that the water in the boiler may be at the proper level. When the test cocks *T T T* are attached to column *Y*, as shown in figure 3, they cease to be reliable when either cock *A* or *C* or the pipe in connection therewith is choked, or nearly choked.

REFERRING TO FIGURE 4 ONLY.

Sometimes the water-gauge fittings are arranged as shown in figures 4 and 5, with no passage up the column, the central portion (*N*) of the column being simply a pillar or connecting piece of any convenient section between the upper and lower portions to which the cocks *B* and *D* are attached.

By this arrangement double communications are obviated and there is no need for what is known as "double shut off" in testing the accuracy of the gauge. When, however, the gauges are constructed in this manner the cocks *B* and *D* are unreliable as test cocks in the event of there being no glass in the gauge. This feature should be carefully noted. Moreover, when in working condition the reduction of pressure in the glass which arises when *E* is opened causes the water in pipe *H* to rise above its normal level. This objectionable feature should also be noted.

REFERRING TO FIGURE 5 ONLY.

Sometimes there is a bend *L* in the steam pipe *I* leading from cock *A* to cock *B*. This has occasionally escaped observation when new boilers have been fitted on board ship. In most cases this bend arises from the pipe being led in an abnormal direction to escape other pipes, beams, or fittings near the smoke box. With such a bend the condensed steam collects in the pipe and falls to the bottom of the bend, and in time it completely fills the pipe from *J* to *K*. The steam from *K* down to the level of the water in the glass is thereby trapped

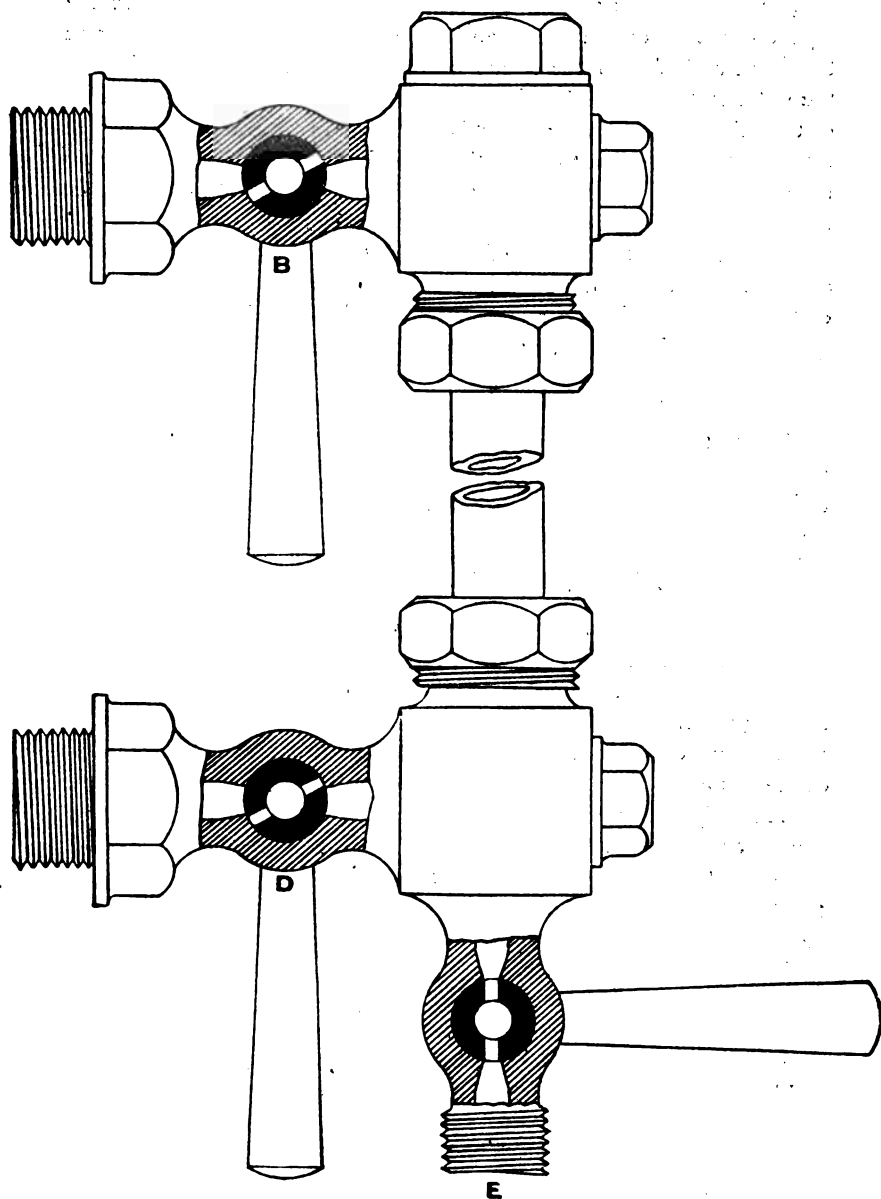


FIG. 6.

und, as condensation proceeds, leads to a reduction of pressure in the pipe below that of the boiler and an equivalent rise of the water in the bend and also in the gauge glass. When the vessel is quiescent the water in the gauge glass increases in height until cock *E* is opened, or until the pressure in the boiler is so much in excess of that in the lower part of pipe *I* as to cause the water in the bend to be blown into the gauge glass. In either case instantaneous change of water level in the glass ensues.

In the ordinary course of working the phenomenon described above is more or less modified by the presence of air in the upper part of the gauge and by the rise and fall of the water in the boiler and gauge glass arising from the rolling or pitching motions of the vessel.

OTHER SPECIAL POINTS TO BE NOTED.

When the cocks *A* and *C* are omitted, as in figure 2, it is owing to the bore of the stand pipe being sufficiently large to enable it to be regarded as part of the boiler. Such pipes require, however, to be examined and cleared at intervals by passing a rod through the holes provided for the purpose at *PP* and *QQ*.

Cocks at *A* and *C* are not necessary for the testing of gauges arranged as shown in figures 4 and 5. Examiners ought, however, to make sure that candidates are aware of the impossibility of testing the reliability of the indications of water-gauges arranged as in figure 3 when the cocks *A* and *C* are absent and of the effect which the choking of cock *A* or *C*, or pipe *H* or *I*, has on the indications of the test cocks *TTT* attached to column *Y*.

Probably more than half the steamers afloat are fitted with water-gauges as shown in figures 3 and 4, and it is therefore specially important that engineer candidates should thoroughly understand their construction, the principle on which they act, and the steps which must be taken to keep them in an efficient condition.

When fitting a gauge glass into its place it is specially important that it should not be placed so high as to prevent a clearing rod being inserted at *G* of the various figures. This defect, especially if it occurs in a water-gauge attached to a boiler subject to priming, permits a rapid accumulation of scum around the top of the glass and results in the choking of the orifice leading from cock *B* to the gauge glass in each of the figures.

When a gauge glass is too short, or is placed either too high or too low in the fittings, it is also liable to become choked by the packing material being forced over its ends by the glands whilst being screwed up.

The use of unsuitable or insecure internal pipes in connection either with the ordinary glass gauge cocks of the description shown in figure 1 or with test cocks which are jointed to the boiler itself should also be carefully guarded against.

Boiler casualties have resulted from the cocks *B* and *D* having the parts wrongly placed as shown in figure 6, page 291. In one case of that kind which forms the subject of Report No. 208 under the Boiler Explosions Acts, the engineer in testing the water-gauge omitted to see that the passages in the cocks *B* and *D* were clear *when the handles were in their proper working position*. This defect could easily have been discovered if proper attention had been paid to the condition of the cocks. A defect of this nature may be due to faulty construction originally, or to the handle of the cock having been overstrained, and the neck twisted. Whether the passages in the plugs are fair and clear can, however, be verified in a few minutes. As an illustration, the water cock *D*, figure 6, can be verified by blowing through *E* with *B* shut and then moving the handle of *D* to one side until it is just closed and then to the other side until it is again just closed; the proper working position of the handle is about equally distant from each of the above positions. The other cocks can be verified in the same manner.

Another serious casualty occurred through the handle of the cock *A*, figure 3, having been twisted from its original position relatively to the orifice of the cock, resulting in the cock being shut when apparently open.

When a water-gauge that is clear in all its parts has been thoroughly blown through, the water in the glass rises above the level at which it formerly stood, immediately the drain cock *E* is closed, but if left undisturbed for a time it gradually falls to its former position. The amount of rise which occurs on these occasions depends chiefly on the temperature of the contents of the boiler and on the length of the pipes by which column *Y* is connected top and bottom to the boiler, but in cases where the gauge is of the description illustrated in figures 3, 4 and 5, it amounts in high pressure boilers to about 4 inches, while the time occupied by the water in returning to its former level ranges from 30 to 40 minutes. The cause of this rise is twofold, namely (*a*) the displacement of the comparatively cold water in pipe *H* by hotter and proportionately lighter water from the boiler, and (*b*) a slight condensation of the steam and a corresponding fractional reduction of pressure in pipe *I*. The cause of the gradual subsidence of the water in the glass to its former

level is also of a dual character, namely (a) the cooling of the water in pipe *H*, and (b) the diminution in the condensation of steam in pipe *I* owing to the collection therein of air released from the steam condensed.

These results will, however, be somewhat modified if the water in the boiler is of higher density than in pipe *H*, and this will nearly always be the case owing to the condensation of the steam in the glass and upper fittings of the water gauge, causing the water in the lower part to be fresher than that in the boiler.

The examiner should impress upon candidates the necessity for periodically blowing through the water-gauge on each boiler (no matter what the form may be) in a systematic and thorough manner, and, in cases where a boiler is fitted with two water-gauges, of keeping both in constant use; finally, he should further impress upon them the necessity for keeping the water-gauges well lighted, clean, and in all respects efficient.

APPENDIX F.

DANGERS ATTENDING THE EXISTENCE OF A VACUUM IN BOILERS.

The attention of Examiners of Engineers is called to the following report relating to a fatal accident to an engineer on board a British ship, and they are requested to see that all candidates for engineers' certificates realise the danger of removing a manhole door without taking the necessary precautions.

Board of Trade Surveyors' Office,
79, Mark Lane,
London, E.C.,
December 1st, 1898.

SIR,

We beg to report that in accordance with your instructions we visited the s.s. *Elderslie*, O.N.89,929, and inquired into the cause of the death, at Smyrna, of Ernest Marshall, third engineer of that steamer, on the 15th October, 1898.

The *Elderslie* is a screw steamer, built in 1884, of 2761 tons gross and 1801 tons net register. The engines are compound, direct-acting, and there are two double-ended boilers of the usual marine type, each boiler having six furnaces, three at each end, W.P. 90 lbs. Mr. E. Marshall, the third engineer, was found dead in one of the boilers under circumstances which are not readily understood.

The chief engineer, Mr. Bishop, repeated to us a statement which he had previously made, and he was corroborated, so far as his personal knowledge went, by the second engineer, and also by a Greek fireman, Spiloni, and the other firemen in the engine room and stokehold at the time. It is clear that on the vessel's arrival at Smyrna on the 14th October, after the fires had died out, the boilers were blown down between 5 and 6 p.m., and by the instructions of the chief engineer, the third engineer proceeded at 7 a.m. on the following morning to take the manhole doors off. (The manholes are 16½ inches by 12½ inches, and are in the end plate at the after end of the boiler.) He was assisted by Spiloni, who was usually detailed to work with him, and who says that one nut and one dog or cross-bar had been taken off the door, and the other nut started, when the third engineer sent him to prepare to take the door off the manhole of the other boiler.

Spiloni left the third engineer, went down a ladder into the stokehold, across the stokehold, up another ladder to the starboard boiler, and immediately afterwards, hearing a loud report, went back to the port boiler where he had left the third engineer, and saw nothing but that the door was off and not in sight. What happened in the interval between this fireman leaving the third engineer and his return in a few minutes can only be reasoned out from the conditions and circumstances of the case as there is nothing definitely known.

The engineers and engineers' crew were at this time engaged as follows :—

Chief engineer on deck.

Second engineer in engine room at high-pressure cylinder ; one fireman with second engineer ; one fireman with third engineer ; four firemen cleaning engines, and two trimmers cleaning tubes in boilers.

The second engineer in the engine room heard the report—he says, about 7.15 a.m.—and describes it as being like the sound caused by coal falling in the bunkers. The chief engineer knew nothing until informed that the third was missing. Spiloni and others had been looking about and inquiring for him. The chief joined in the search and finally went to the manhole, when he noticed that the door was off, and not to be seen. He states that the boiler was so hot inside that he could not keep his hand in, and that on trying to put his head in the manhole he found it impossible to do so. Hot vapour was coming out of the manhole. His first thought was that the third engineer had allowed the door to drop into the boiler, and, attempting to get it out, had gone into the boiler, and been overcome by the heat. He tried to look in with lamps, etc., but could not see anything. He then got the bottom doors off, first the after bottom door and then the forward one. He could not see anything through the after door, but on looking in the forward bottom door he saw blood on the sides of the furnaces—that is, he explains there was some fresh blood as if running down on the side of the centre and wing furnace near to the forward end of the boiler. This was at 7.45 a.m. The boiler was allowed to cool down and in about four hours the body of the third engineer was got out. It was found lying on two of the longitudinal stays close to the forward end plate, and opposite the manhole. The door was found on the top of the tubes almost underneath the body, and one of the dogs beside it—both of the studs in the door were bent and a small piece of rope was fastened to one of the studs. A spanner was found on the top of the combustion box girders—that is halfway

between the manhole and the position of the body, and a lamp, hammer, and chisel and broom-head or brush were found in the bottom of the boiler. When the body was got out it was found that the skull was fractured, and that the skin where exposed peeled off when rubbed. A surgeon certified that the skull was fractured but does not appear to have examined the whole body, contenting himself with seeing sufficient cause for the man's death. The master, however, says that the arms and shoulders looked to him as if seriously injured or broken, and there was a deep mark on the forehead and the clothing torn in places.

The foregoing statement contains the important points of the case so far as we can gather them. We both have entered the boiler, examined the manhole and door, had the exact position where the body was found pointed out, and also that of the door, etc., and spanner. The whole story appears straightforward and is easily realised, but the causes which brought the body of the third engineer to the position where it was found are not so readily explained. Accepting the statements of the master, engineers, and firemen (and we have no reason for doubting them), it is clear that the third engineer either (1) got into the boiler of his own accord, (2) was put in by others, or (3) met his death accidentally by causes unforeseen and unnoticed, and which no one contributed to, except himself, and that unknowingly. The first two causes must, it appears to us, be dismissed—the position of the body and the statement as to the high temperature of the boiler and other reasons rendering them absolutely inadmissible; and after considering the whole circumstances of the case, we are of opinion that the death of the third engineer was brought about in the following manner:—

The boilers were blown down and left, neither safety valves nor cocks were opened (the chief engineer says he gave instructions to open the gauge cocks, but found them shut) so that when the steam condensed there would be a vacuum in the boilers. The manhole is in the after end plate, there is a small platform almost in a line with the door. The deceased took off both the nuts without starting the door, one dog was taken off, the other turned partly round, a piece of small rope (which the second engineer says was very weak stuff) was fastened to one of the studs of the door and to the gauge glass stand. He then stooped down in almost a lying position, probably holding the door by one of the studs, or by the rope, with one hand, and perhaps tapping it with the spanner in the other hand, when the door started, was suddenly driven inwards by the pressure of the atmosphere with

great force, the rope broke, and the deceased, involuntarily tightening his grip on the stud or rope, was drawn into the boiler—the inrush of air assisting this movement, as his body became near to or partly filled the hole—and he was propelled with such violence as to fracture his skull on the other end of the boiler, or it may be by striking the plate at the manhole as his head was entering it.

This explanation which, from its singularity may at first appear somewhat doubtful, is the only one which we think fits all the known facts of the case, such as :—The short interval which elapsed between the time when the fireman, Spiloni, left the third engineer and his return to the manhole ; the short time from starting work at 7 a.m. until the report was heard 15 minutes later ; the sudden disappearance of the third engineer ; the condition and position of the body when found, the position of the door, spanner, etc. ; and also the high temperature of the boiler.

It certainly appears extraordinary that a man could be drawn into a boiler through a manhole with such force as to fracture his skull on the end plate, 16 feet from the hole, and in a direct line with it, but the stays would form a sort of guide to keep the door and body travelling in a horizontal and direct line, and it may be added that the deceased was not a big man. He is said to have been about 10 stone in weight and 5 feet 5 inches high. It can be seen by examination of the small platform at the manhole that the occurrence is at least quite possible. At any rate, unless the whole story is disbelieved, a manhole door weighing 85 lbs. was found along with the body of the third engineer, close to the end plate furthest from the manhole, and had been in that position for some hours and from a time when the condition of the boiler was such that no one would have entered it, or could have lived therein.

We wish to add that, although death under the above circumstances is probably unprecedented, the violent inrush of a manhole door due to vacuum in the boiler has been frequently experienced. A case somewhat analogous occurred in one of the steamers of the ——— Line, which hearing about, we inquired as to the facts from the superintendent who kindly sent a letter describing the case, a copy of which is given on opposite page.

We have inquired in reference to the circumstances of this case of the master, first and second engineers, Spiloni, and the other men. The firemen are Greeks, and understand very little English. The present third engineer, who is a native of Smyrna, and can speak English and Greek, acted as interpreter.

The area of the manhole, $16\frac{1}{4}$ inches by $12\frac{1}{4}$ inches, is about 156 square inches, and assuming a temperature of about 180 degrees in the boiler, there might exist an external pressure of 7 lbs. per square inch, which, if suddenly applied, would exert a force of 1092 lbs.—at any rate sufficient force would be exerted to set up a high velocity on the door when suddenly relieved.

Copy of Letter referred to.

Referring to our conversation this morning, relative to the death of an engineer in a boiler on board a British steamer at Smyrna, it affords me some pleasure to give you the details of an almost similar occurrence on board one of the steamers of the ——— Line some few years ago. They are as follows :—

The vessel arrived on a Saturday evening, and it being necessary to get the men in the boiler at the earliest possible moment for cleaning purposes, one of the junior engineers was ordered to the ship on Sunday morning. His instructions were to pump the remaining water out of the boiler, and he did this without admitting air. So far as we were able to gather at the time, it seems that the engineer, together with a Chinese fireman, went to take off the lower manhole door. This door was some few inches above the stokehold floor, and, as is the usual practice of Chinamen, the fireman assumed the "squatting" attitude. He was left to himself to remove the nuts and dogs of the door, and when he had done so, he started the door, and was instantaneously drawn in towards the boiler, his stomach practically closing the aperture, and the door swinging to the back of the boiler with a loud report.

Hearing the fireman's cries, the engineer opened the gauge cocks in order to admit air to the boiler, whilst the fireman in the meantime suffered great agony, being pinned in this position until the vacuum was destroyed.

When the matter was reported to me the next morning, I saw the fireman, who complained of internal injuries. These, however, do not appear to have been of a severe nature, as the man was able to resume his work in a few days.

APPENDIX G.

EXAMINATION OF MASTERS AND MATES IN STEAM.

These examinations are provided for the purpose of giving masters and mates who are possessed of certificates of competency an opportunity of undergoing a voluntary examination as to their practical knowledge of the use and working of the steam engine. The examiners are selected by the Board of Trade from the engineer surveyors appointed under the fourth part of the Merchant Shipping Act, 1894.

The examination is open to any person who holds a certificate of any grade in the foreign or home trade or as master of his own pleasure yacht. Candidates should fill up the form of application, form Exn. 2, at a Mercantile Marine Office, pay the fee of £1, and deposit their certificates and testimonials with the superintendent. The superintendent will inform the applicant when and where to attend to be examined. If the candidate fails to pass his certificate will be at once returned to him.

If he passes, the report (Exn. 15) will be sent to the Chief Examiner of Engineers, and the certificate, together with the form Exn. 2, will be sent to the Registrar-General of Seamen; the words, "Certified to have passed in Steam," with the date and place of examination, will then be entered on the certificate and its counterpart, and the certificate will be sent to the Superintendent of the Mercantile Marine Office of the port named in the form Exn. 2, and be delivered to the candidate in the usual manner.

If a candidate fails he may not present himself for re-examination until the expiration of three months from the date of failure.

The examination is for the most part *viva voce*, and extends to a general knowledge of the practical use and working of the steam engine, and of the various valves, fittings, and pieces of machinery connected with it; and of the way in which electric lighting is carried out on board ship. Theoretical questions on calculations of horsepower or areas of cylinders and valves, or any of the more difficult questions relating to steam engines and boilers, will not be asked.

Examiners are to satisfy themselves that the candidates know the names and understand the uses of the various parts of the engines and boilers, and their connecting pipes, valves, cocks, etc. Practical knowledge, as distinguished from theories and abstruse calculations, is to be the test of the candidate's fitness to have his certificate endorsed.

The examiner should arrange to conduct part of the examination in the engine room of a steamship, unless, from circumstances, he finds it impossible to do so; but in the event of the candidate passing, the examiner should state in writing what circumstances prevented a visit to an engine room. If an opportunity offer, the candidate should be permitted, under the guidance of the examiner, to start and stop the engine of some vessel which may have her steam up.

The examiner, in sending in his report of the examination, should state where the examination has been held.

Candidates will be required to give written answers to sixteen out of twenty questions taken from the elementary questions printed in this book. These questions will be altered from time to time without notice. The twenty questions are not to be difficult, theoretical, or book questions, but are to be such as any man of ordinary capacity, who has any practical knowledge of the use and working of the steam engine, ought to answer.

These questions, with the candidates' answers, should be sent to the Chief Examiner of Engineers, with the reports, after each examination.

If a candidate refers to any book or paper or memorandum, or obtains information from another candidate or any other person during the examination, he will be treated as having failed, will forfeit his fee and will not be allowed to be re-examined for a period of three months.

The examiners will report in the case of failure, the nature of the question or questions that decided the failure, or the point in the management of the engine in which the candidate was deficient.

There is nothing in the regulations requiring that applicants for the voluntary examination shall have served on board steamships; all that is required is that they shall have a practical knowledge of the use and working of the steam engine. Examiners will not fail to appreciate the fact that practical knowledge is best gained in the engine-room; and the examination of an officer who does not produce official evidence of service in steamships, and of experience of engines, must necessarily be more searching than in the case of one who produces evidence of such service and experience.

Examiners will require all candidates to fill up a form Exn. 15 *b.*, and they will forward it to the Chief Examiner of Engineers with the report of the examination.

Masters and mates may cancel questions A, B, and C, but they should fill up the form for questions D, E, F, and G, as evidence of their practical knowledge.

A candidate for this examination is required to have a thorough

grasp of the construction of the steam engine and boiler, to enable him, in the first place, to understand the nature and importance of any defect which may be reported to him by the chief engineer, and so that he may work in harmony with him in affording time and facilities for disconnections, inspections, adjustments, and repairs ;

to have a looking-on knowledge of what the principal repairs are about engines and boilers and pipes, and how these repairs are accomplished ;

to be able to form an independent opinion as to a breakdown, and the consequent propriety or impropriety of proceeding under steam with temporarily repaired or defective machinery ;

to understand how to estimate approximately the reduction of fuel required for reduced speed, and consequently to sanction such reduction of speed as may seem to him to be warranted by the report of the chief engineer, and to satisfy himself before leaving port that there is sufficient coal for the voyage ;

to have an intelligent grasp of the general run of pipes and connections in the engine room, the marking of cocks, the opening and closing of cocks and valves, how mistakes of importance may be made in the confusion of an accident, and how best to guard against such mistakes ;

to be capable of being left in charge of the feeding of a set of boilers, to understand the working of the water gauge, and to be able to guard against being misled by false indications of the gauge glass ;

to understand about blowing down and surfacing, the reasons for doing so, and the danger which may result from the neglect of these under certain circumstances.

A master or mate presenting himself for examination in steam must be understood to have made up for his want of practical experience by reading up about the steam engine. He ought, therefore, to show that he has given his mind to intelligently understanding the *rationale* of the action of the steam engine. Under this head he should, therefore, be able to state approximately the quantity of heat required in the formation of steam, the remarkable relation of "latent" heat to "sensible" heat, how much steam can be raised by the combustion of one pound of coal, what horse-power measure is, what indicated horse-power is, what is the action of the slide valve, the course of the steam through the engine, and the advantage of working expansively, and how the expansive action is shown by the indicator diagram. To know the uses of the various parts of the engines and

dynamos used for electric lighting, and how they and the cables are fitted in the hull ; how wires are jointed, insulated, and cased ; why it is desirable that they should be led along places which are dry and accessible ; what is "short circuiting," and what are the causes which produce it ; what is its danger in coal bunkers and petroleum carrying steamers ; what are the uses of switches and cut-outs, and why is it so important to prevent short-circuiting taking place.

The candidate has to answer in writing 16 out of 20 questions selected from the elementary questions as given in this book.

Selections for this examination are given on the alphabetic sheet for "Steam." Generally, these answers are given by candidates as learned by rote from a book ; the candidate should therefore be asked such *viva voce* questions as will necessitate his giving his answers in different words, so as to discover whether he has the root of the matter in him.

The principal part of the *viva voce* is the examination on board a steamer, preferably one with which he is unacquainted. He is told to look about and try to find out the run of the machinery without the assistance of anyone ; the examiner to be in the engine room to see that this independent examination is properly carried out. When the candidate reports that he thinks he knows the whole arrangement of the machinery, the examiner will then question him on the uses of the parts, get him to point out the different cylinders, pumps, valves, condenser, etc. ; also the dynamo, its field magnets, armature, commutators, brushes, cables, etc. He must show that he understands the run of the pipes in the bilges, not necessarily that he has gone over every one of them, but he ought to be directed to trace, at least, one important range of pipes, and to thoroughly satisfy the examiner that he could be safely trusted to manipulate the valves or cocks in connection therewith. It will not often be practicable for the candidate to be asked to actually work engines under steam, but he must satisfy the examiner that he knows how to do so, and that he is aware what precautions have to be taken in regard to water in the cylinder, etc. It is most important that a candidate should show that, in the event of an accident depriving him of the assistance of engineers, he knows what to do to safely take his vessel to an anchorage, or to stop the engines and proceed under sail alone.

The examination of a mate in steam is the same as that of a master. The knowledge required has no reference to the mate's position. A mate may be examined, but such examination implies that the mate will one day be a master, when the possession of the knowledge will be an advantage to him in the discharge of his duties as master.

APPENDIX H.

LIST OF COLONIAL CERTIFICATES ISSUED UNDER ORDER IN COUNCIL,
which are of the same force as those granted by the BOARD OF TRADE.

Colony.	CERTIFICATES.		Date of original Order in Council.	Date from which Order in Council takes effect.
	By whom granted in Colony.	Description.		
Victoria ..	*Marine Board.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	30 Mar. 1871	4 Jan. 1870
Canada ..	The Minister of Marine and Fisheries.	Master; Mate† 1st Class Engineer; 2nd Class Engineer.	19 Aug. 1871 10 Nov. 1886	19 Aug. 1871 1 Jan. 1887
New Zealand	Marine Department.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	9 Aug. 1872	1 May 1872
New South Wales	‡Department of Navigation.	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	30 Aug. 1873	18 June 1872
Malta ..	The Head of the Government.	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	12 May 1874	12 May 1874
South Australia	Marine Board.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	12 May 1874	12 May 1874
Tasmania	The Governor.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	12 Feb. 1876	1 April 1876
Bengal ..	Lieutenant-Governor.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	27 June 1876	27 June 1876
New-foundland	Governor.	Master; 1st Mate; Only Mate; 2nd Mate. 1st Class Engineer; 2nd Class Engineer.	14 May 1877 19 July 1910	14 May 1877 19 July 1910
Bombay ..	Governor.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	11 July 1877	11 July 1877
Queensland	Marine Board.	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	26 Mar. 1878	1 Oct. 1877
Hong Kong	Governor.	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer.	31 Dec. 1883	1 Jan. 1884
Straits Settlements	Governor.	Master; 1st Mate; 2nd Mate. 1st Class Engineer; 2nd Class Engineer.	1 May 1890 do. do.	1 June 1890 1 Aug. 1888
§Mauritius	Governor.	Master; 1st Mate; 2nd Mate.	22 Nov. 1890	1 Jan. 1891

*The Steam Navigation Board was superseded by the Marine Board on the 21st December, 1883. See Order in Council of 23rd November, 1893.

†Equivalent to First Mate.

‡The Marine Board was superseded by the Department of Navigation on the 17th March, 1900.

§Mauritius does not issue Engineer Certificates under the Order in Council.

APPENDIX K.

The following is a list of technical schools, attendance at which is recognised by the Board of Trade as affording remission of some period of the service required to qualify a candidate for examination for a certificate of competency as engineer.

(I.) DAY CLASSES.

When nothing is stated to the contrary, time spent in attending the day classes in mechanical engineering of a recognised technical school is accepted as equivalent to artisan service at the ratio of three years of the former to two of the latter, provided the applicant was over 15 years of age and can produce the principal's certificate for continuous and regular attendance at all the approved classes and for satisfactory progress. Such time cannot as a rule be accepted as equivalent to more than two years' artisan service.

Name of School or Institution.

Belfast.—Municipal Technical Institute, Belfast.

*Birmingham.—University of Birmingham.

†Birmingham.—City of Birmingham Municipal Technical School,
Suffolk Street, Birmingham. (Afternoon classes.)

‡Bombay.—Victoria Jubilee Technical Institute, Bombay.

Bradford.—Municipal Technical College, Bradford.

Brighton.—Municipal Technical College, Brighton.

Bristol.—Merchant Venturers Technical College, Bristol.

Bristol.—University College, Bristol.

§Cardiff.—City of Cardiff Day Preparatory Technical School, Cardiff.

Cardiff.—University College of South Wales and Monmouthshire,
Cardiff.

||Devonport.—Royal Naval Engineering College, Devonport.

* Time spent by students of the electrical engineering department on work similar to that in the mechanical engineering department to count as equivalent.

† Time spent at afternoon classes to count as equivalent to two-thirds of the same period of workshop service, five hours in the classes being reckoned as equivalent to one day.

‡ Half the time only to be counted.

§ One-sixth of the time only to be counted.

| Time to count in full up to three years, or in the case of students who were in training in or before September, 1908, up to four years under the following conditions:—

(a) A certificate of practical workmanship and good conduct must be produced.

(b) A student must have been at least 20 on the completion of his training.

(c) Any deficiency in workshop service to be made good by service as engine fitter in shops where steam engines are made or repaired.

*Dublin.—Pembroke Day Trades Preparatory School, Ringsend, County Dublin.

Edinburgh.—Heriot-Watt College, Edinburgh.

Exeter.—Junior Engineering and Technical School of University College, Exeter.

†Glasgow.—Royal Technical College, Glasgow.

†Glasgow.—James Watt Engineering Laboratories, Glasgow University.

Huddersfield.—Huddersfield Technical College, Huddersfield.

Hull.—Municipal Technical School, Hull.

Leeds.—The University of Leeds.

Liverpool.—The Faculty of Engineering, The University of Liverpool, Liverpool.

London.—Battersea Polytechnic, London, S.W.

London.—Central Technical College, London, S.W.

London.—City and Guilds Technical College, Finsbury, E.C.

London.—East London College (University of London), Mile End Road, London, E.

‡London.—Day Technical School for Boys, Borough Polytechnic Institute, 103 Borough Road, London, S.E.

§London.—Electrical Standardising Testing and Training Institution, Southampton Row, London, W.C.

||London.—King's College, Strand, London, W.C.

London.—London County Council School of Engineering and Navigation, Poplar, London, E.

‡London.—Day Technical School for Boys of London County Council School of Engineering and Navigation, Poplar, London, E.

¶London.—Northampton Polytechnic Institute, Clerkenwell, London, E.C.

London.—Polytechnic School of Engineering, Regent Street, London, W.

*London.—St. Olave's Grammar School, London S.E.

London.—South Western Polytechnic, Manresa Road, Chelsea, London, S.W.

* One-third of time to count with a maximum of one year.

† A complete session to count as six months.

‡ One-third of the time only to be counted.

§ Half the time only to be counted.

|| Two-thirds of time to count, with a maximum of two years for three-year students, and two years and eight months for four-year students who have spent three summer sessions in the works of a maker of steam engines, for which no separate allowance is claimed.

¶ Two-thirds to count with a maximum of two years eight months.

- London.—University College, Gower Street, London.
- *Londonderry.—Municipal Day Trades Preparatory School, Londonderry.
- Manchester.—Manchester Municipal School of Technology, Manchester.
- Manchester.—Owens Technical College, Manchester.
- Newcastle-on-Tyne.—Armstrong College, Newcastle-on-Tyne.
- †Newcastle-on-Tyne.—Rutherford Technical College, Newcastle-on-Tyne.
- ‡Oundle.—Engineering Department of Oundle School, Northants.
- Portsmouth.—Portsmouth Municipal College, Portsmouth.
- Salford.—Royal Technical Institute, Salford.
- Sheffield.—University of Sheffield, Sheffield.
- Sibpur.—Civil Engineering College, Sibpur, Bengal.
- Southampton.—Hartley University College, Southampton.
- Sunderland.—Sunderland Technical College, Sunderland.
- Swansea.—Swansea Technical College, Swansea.
- West Ham.—Municipal Technical Institute, West Ham.

(II.) EVENING CLASSES.

Time spent in attending Evening Classes in Engineering at approved Technical Schools is accepted as equivalent to workshop service, five hours in the classes being reckoned as equivalent to one day, and two-thirds of the number of days so obtained counting as workshop service, subject to the provisions laid down in paragraph 39 as amended.

Name of School or Institution.

- Belfast.—Municipal Technical Institute, Belfast.
- §Birmingham.—City of Birmingham Municipal Technical School, Suffolk Street, Birmingham.
- Brighton.—Municipal Technical College, Brighton.
- Bristol.—Merchant Venturers Technical College, Bristol.
- ||Cardiff.—City of Cardiff Technical Schools.
- Dundee.—Dundee Technical College, Dundee.
- Edinburgh.—Heriot-Watt College, Edinburgh.
- Glasgow.—Royal Technical College, Glasgow.

* One-third of the time only to be counted.

† A complete session to count as four months.

‡ One-third of time to count with a maximum of one year.

§ Afternoon classes also count in the same proportion.

|| Time spent by students of the Electrical Engineering Department on work similar to that in the Mechanical Engineering Department to count as equivalent.

Greenock.—Greenock Technical School, Greenock.
 Huddersfield.—Huddersfield Technical College, Huddersfield.
 Leeds.—University of Leeds.
 Leith.—Leith Technical College, Leith.
 Liverpool.—Municipal Central Technical School, Liverpool.
 London.—Battersea Polytechnic, London, S.W.
 London.—Borough Polytechnic Institute, 103 Borough Road, London, S.E.
 London.—London County Council School of Engineering and Navigation, Poplar, E.
 London.—Northampton Polytechnic Institute, Clerkenwell, E.C.
 London.—The Polytechnic School of Engineering, 307, 309, and 311 Regent Street, London, W.
 London.—South Western Polytechnic Institution, Manresa Road, Chelsea, S.W.
 Londonderry.—Municipal Technical School, Londonderry.
 Manchester.—The Manchester Municipal School of Technology, Manchester.
 Newcastle-on-Tyne.—Armstrong College, Newcastle-on-Tyne.
 Newcastle-on-Tyne.—Rutherford Technical College, Newcastle-on-Tyne.
 Preston.—Harris Institute, Preston.
 Salford.—Salford Royal Technical Institute, Salford.
 Sheffield.—Department of Applied Science, University of Sheffield, St. George's Square, Sheffield.
 Southampton.—Hartley University College, Southampton.
 South Shields.—The Marine School, South Shields.
 Swansea.—Swansea Technical College, Swansea.

(III.) MARINE TECHNICAL SCHOOLS.

When nothing is stated to the contrary, time spent at a Technical School recognised as suitable for the training of Marine Engineers will, subject to the provisions laid down in paragraph 33 of the Regulations, be allowed to count as sea service in the ratio of three months at the Technical School to two months at sea, time so spent not to be accepted as equivalent to more than one-sixth of the total sea service required for a certificate.

Name of School or Institution.

Greenock.—Watt Memorial School, Greenock.
 South Shields.—The Marine School, South Shields.

APPLICATION TO BE EXAMINED FOR AN ENGINEER'S CERTIFICATE OF COMPETENCY.

(A).—Name, etc., of Applicant.

Christian Names at full length. 1	Surname. 2	Permanent Address, stating Town, Street, and No. of House, and name of person (if any) with whom residing. 3
<i>Edward William</i>	<i>Thompson</i>	<i>47 Wessex Street, Newcastle-on-Tyne. (Parents.)</i>

DATE OF BIRTH.			WHERE BORN.	
Day. 4	Month. 5	Year. 6	Town. 7	County. 8
<i>16</i>	<i>March</i>	<i>1889</i>	<i>North Shields</i>	<i>Northumberland</i>

(B).—Particulars of all previous Certificates (if any) whether issued in the United Kingdom, the British Possessions, or elsewhere.

Number	Competency or Service, or R.N.E.	Grade.	Where Issued.	Date of Issue.	If at any time suspended or cancelled, state by what Court or Authority.	Date.	Cause.
9	10	11	12	13	14	15	16

NOTE BY AUTHOR.—If applicant is sitting for Second he runs his pen through all these, but if sitting for Chief all the particulars needed for filling in these blanks he obtains from his Second Class Certificate.

(C).—Certificate now required.

Grade. 17	Mercantile Marine Office to which it is to be sent. 18
<i>Second Class or First Class as the case may be.</i>	NOTE BY AUTHOR. —Whichever office is the most suitable for the candidate.

APPLICATION TO BE EXAMINED, ETC.—*Continued.*

(D).—If Applicant has failed in a previous Examination for the Certificate now required, he must here state when and where. If he has not failed he must state so in writing across this Division.

Day.	Month.	Year.	Port.	Subjects in which he failed.
19	20	21	22	23

NOTE BY AUTHOR.—When sitting the exam. for the first time write across here—"I have not failed." Otherwise give all particulars as to previous attempts.

(E).—Superintendent to Examiner.

The Declaration (I.) has been signed in my presence, and the Fee of £ received by me.

Dated at.....this.....day of.....19.....

.....Superintendent.

(F).—Certificate of Examiner.

NOTE.—The Examiner should fill up Divisions (F) and (G), and in all cases forward this paper as soon as possible to the Registrar-General of Shipping and Seamen, Custom House, London, E.C. If the Candidate passes, his Testimonials and previous Certificate (if any) must be sent attached to this paper. The new Certificate and the Testimonials will be delivered to the Candidate at the office named in Division (C) col. 18.

Date and Place of Examination.		Insert passed or failed in each Column.		Rank for which passed.
Date.	Place.	In working out the Questions.	In the <i>viva voce</i> Examination.	
24	25	26	27	28

(G).—Personal Description of Candidate.

Height.		Complexion. 31	Personal Marks, or Peculiarities, if any. 32	Colour of	
Feet.	Inches.			Hair. 33	Eyes. 34
29	30				

NOTE BY AUTHOR.—Copy in the particulars as they are given in Discharge Book.

I hereby certify that the particulars contained in Divisions (F) and (G) are correct, and that the Candidate has produced satisfactory Testimonials and proofs of service.

Dated at.....this.....day of.....19.....

To the Registrar-General of Shipping and Seamen,
Custom House, London, E.C.

{ Signature of
Examiner.

APPLICATION TO BE EXAMINED, ETC.—*Continued.*(B).—List of Testimonials and Statement of Service on
Shore and at Sea.(The Testimonials to be numbered consecutively according to the number given in
Column 35 below.)As a rule the Discharge Certificate (Form Dis. 1) will be accepted as proof of Foreign Trade Service,
but Home or Coasting Trade Discharges should always be sent to the Registrar-General
of Seamen for verification.

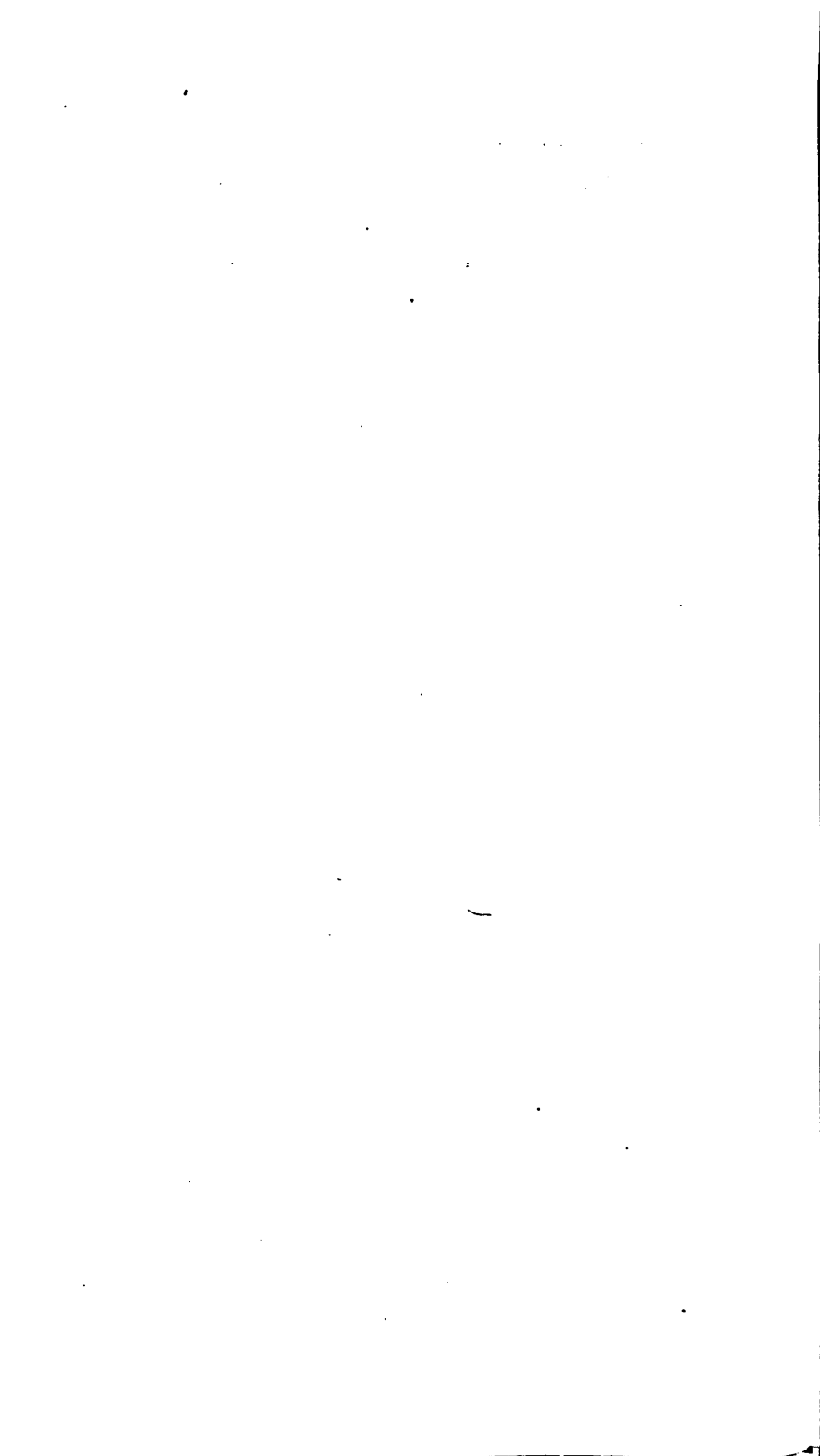
No. of Testimonials, if any.	Where Employed or Ship's Name.	If Service on Board Ship.		Service of Candidate.						Trade in which employed.	Remarks.	Initials of Verifier.
		Horse-power of Engines.	Port of Registry and Official No. of Ship.	Capacity.	Date of Commencement.	Date of Termination.	Length of Service.					
							Years.	Months.	Days.			
35	36	37	38	39	40	41	42	43	44	45	46	47
1	Apprenticeship Messrs.....	served at of			4-3-05	4-3-09	4	—	—			
2	Journeyman at of	Messrs.....			12-3-09	7-7-10	1	3	25			
3	Out of Employ me nt				7-7-10	9-9-10		2	2			
4	s.s. "Tyne," {	480 Cardiff h.p. No. 106434		3rd eng.	12-9-10	16-11-10		2	4		Bl'k Sea.	
5	" " {	" " "		"	18-11-10	3-1-11		1	15		"	
6	Out of Employ me nt				5-1-11	7-2-11		1	2			
7	s.s. "Wear," {	380 Cardiff h.p. No. 114071		3rd	3-3-11	4-2-12		11	1		Trading	
8	s.s. "Tay" {	900 London h.p. No. 114976		3rd	1-3-12	8-10-12		7	7		"	
	At school preparing	for Examination			5-11-12	3-1-13		1	28			
Total Service at Sea, ...							1	9	27			
Ditto on Shore, ...							5	3	25			
Time served for which Official Proof now produced, ...							1	9	27			
Time served for which no Proof is produced, ...												

Dated at North Shields this 5th day of January, 1913.

EDWARD WILLIAM THOMPSON, Signature of Applicant.

47 Wessex Street, Newcastle-on-Tyne, Present Address.

NOTE BY AUTHOR.—The above has been filled up as for a Second Class Applicant. Chiefs simply write at the top the sea time they had in when passed for Second, and then go on with all the voyages and gaps (if any) in proper order of dates. All gaps of more than one month's duration must have a testimonial to state where the candidate was during such time. These must be given by some responsible person acquainted with the facts.



INDEX

	PAGE		PAGE
Absolute pressure of steam ...	30	Ammonia machine, fans for cold	
Absolute pressure of vapour in condenser ...	128	air with... ..	191
Accumulator, steam hydraulic ...	228-231	Ammonia machine, "Battery"	
Accumulator, electric for ignition ...	244	system of cooling ...	191
Acids in boiler, neutralised by soda ...	73	Amount of lead ...	118
Action of air vessels ...	98	Amount water can be compressed ...	160
Advantage of large rose over a small one ...	149	Ampere, definition of ...	223
Advantage of independent feed pumps ...	204	Angle irons used in boilers ...	18
Air expansion cylinder cold air freezer ...	194	Annealing of steel ...	7
Air valve for circulating pump ...	50	Application form, showing method of filling in ...	309-311
Air pump, double acting ...	51	Arc lamp, description of ...	222
Air pump trunk ...	51	Area of safety valve required ...	25
Air pump valves ...	53	Armature of dynamo ...	211
Air pump, Edward's ...	54	Armature, use of ...	225
Air pump, leaky foot valve ...	59	Ash ejector ...	201
Air pump pet cock ...	59	Aspinall's governor ...	234
Air pump bucket ...	68	Assistant cylinder ...	94
Air pump rods, material of ...	68	Atmospheric pressure ...	115
Air pump, height of water in ...	69	Atmospheric pressure affecting gauge readings ...	127
Air pump discharge valve ...	110	Automatic glass water gauge ...	168
Air vessels, good and bad types ...	98	Automatic feed regulator ...	172
Air vessels, where placed ...	98	Automatic feed pumps ...	204
Air vessels, function of ...	158	Back pressure in condenser, finding ...	125
Air tight lid for mud box ...	99	Back pressure in cylinder ...	114
Air, more, for Welsh coal ...	135	Bad air in tanks, etc. ...	148
Air heating, forced draught ...	141	Balance piston and cylinder ...	94
Alloys and elements, difference between ...	4	Barometer, construction, etc. ...	125
Ammeter ...	228-229	Bars, furnace ...	134
Ammonia freezing system ...	180-184	Babcock & Wilcox water-tube boiler ...	165, 166, 167
Ammonia, latent heat of ...	181	Babcock & Wilcox water-tube boiler, description of ...	166
Ammonia, defects with ...	181	Babcock & Wilcox feed regulator ...	172
Ammonia machinery, isolation of ...	182	Belleville boiler, economiser with ...	166
Ammonia gas, removal from tubes ...	183	Bilge injection ...	60
Ammonia gas, objection to water ...	184	Bilge pipes ...	62
Ammonia machine, materials used ...	184	Bilge water in double bottomed vessel ...	149
Ammonia machine, no escape valves used with ...	186	Bilge suction to both wings of bilge ...	150
Ammonia machine, no white metal allowable with ...	186	Bilge boards, effect of flood water upon ...	151
Ammonia machine, maximum pressure with ...	186	Blast pipe ...	22
Ammonia machine, pressure and other gauges with ...	186	Block, thrust ...	85
		Block, thrust, "Michel" ...	86
		Blow through valve ...	64
		Blow off cocks and guards ...	22
		Board of Trade Regulations ...	253-308

	PAGE		PAGE
Boards, bilge, effect of flood water upon	151	Cause of leaky boiler tubes	14
Boiler tubes, fixing of	13	Cause of cracked tube plates	14
Boiler salting	30	Cause of local heating in electric wires or leads	227
Boiler, thin places in	12	Centrifugal circulating pump	49, 51
Boiler deterioration due to rusting, acids, etc.	13	Centigrade thermometer	130
Boiler, fittings on	91	Check valve, defective	35
Boiler, haystack type	108	Check nuts on expansion joint	83
Boiler not receiving proper amount of feed	134	Check valve, unadjustable	112
Boiler, danger with internal pipes	160	Circulating pump	48
Boiler pressure higher than at engines	168	Circulating pump, failure of	65
Boiler, water tube type	166-167	Circulation in ordinary boiler	107
Bolts, holding down of thrust	155	Circulation, how improved	107
Bourdon pressure gauge	28	Circulation in haystack boiler	108
Brass, where used	2	Class of pumps fitted with escape valves	157
Brass liners on tail end shaft	87	Cleaning test cocks	23
Breaking stress	5	Cleaning water gauge pipes	161
Brine system of freezing	190	Cleaning filter	206
Brine, composition of	190	Cleaning coils of evaporator	211
Brine grids in holds, modern arrangement of	192	Clothing water gauge pipes	161
Brine, removal of, from evaporator	210	Clutch for oil motor installation	247
Brushes, use of	212, 225	Coal, consumption of, in lbs. per hour per I.H.P.	103
Bucket air pump	50	Coal, consumption of, from area of grate	135
Bunker, gas in	147	Coal, consumption of, from size of ship	137
Bunker, explosion in	147	Coal, consumption of, from size of engines	138
Bunker, badly ventilated	147	Cock on steam gauge	29
Cam shaft of oil motor	239	Cocks and valves on skin of ship	91
Candle power of glow lamps	223	Cocks and valves to open before starting	92
Cap on safety valve	24	Cocks and valves through which feed passes, jet condenser	96
Carbonic acid gas freezer	188	Cocks and valves through which circulating water passes	96
Carbonic acid gas, how removed from tubes	188	Cocks and valves through which feed passes, surface condenser	97
Carbonic acid gas, objection to water	188	Cocks, test	23, 160
Carbonic acid machine, what materials can be used	189	Cocks, test, danger with internal pipes	160
Carbonic acid machine, escape valves with	189	Cohesive strength	5
Carbonic acid machine maximum pressure	189	Cold holds, finding temperature of	191
Carbonic acid machine, why pressure must rise when sea water temperature rises	189	Cold holds, insulation of	196
Carbonic acid machine, kind of gauges used	190	Cold air with CO ₂ or NH ₃ machines	191
Carbonic acid machine, brine used with	190	Cold air process of refrigeration	193
Carbonic acid machine, fans for cold air with	191	Cold air process of refrigeration, material of valves	194
Carbonic acid machine, "Battery" system of cooling	191	Cold air process of refrigeration, number of compressors	194
Carburettor of oil motor	239	Cold air process of refrigeration, duty of expansion cylinder	194
Case hardening	6	Cold air process of refrigeration, removal of water	195
Cast steel pistons	38	Cold air process of refrigeration, pressure with	195
Cast iron, where used	1	Cold air process of refrigeration, kind of gauges	195
Cast iron floats in paddle wheel	77	Common paddle wheel	76
Catchwater	67	Common style of paddle engines	81
Caulking	9	Commutator, use of	212, 225

INDEX

315

	PAGE		PAGE
Commutator, construction of	211, 212	Dial vacuum gauge	124
Comparison between forced and induced draught	142	Diesel engine, oil consumed with ...	103
Compound engine	40	Difference between air pumps ...	50
Composition of explosive gas ...	147	Difference between salting and scaling of a boiler	30
Compression or cushioning ...	122	Difference between cast and wrought iron and steel	3
Compressor piston rods, swabbing of	192	Difference between mean pressure and mean effective pressure ...	124
Compressors with cold air freezer	194	Difference between horse power for rudder going ahead and going astern	233
Condenser, hot	63	Different properties of iron and steel	4
Condenser surface, economy with	103	Difficulty in keeping steam with a heavy list	150
Condenser surface, construction of	104	Difficulty with carbonised oil in oil motors	250
Condenser surface, where foul and how cleaned	105	Difficulty in starting oil motor ...	246
Conduction of heat	131	Discharge valve, air pump	110
Consumption of fuel, lbs. per hour per I.H.P.	103	Disconnecting paddle engine ...	80-81
Consumption of coal from area of grate	135	Distinguishing between iron and steel	3
Consumption of oil fuel	136	Distinguishing between zinc, brass, and silver	3
Consumption of coal from size of ship	137	Distinguishing between alloys and elements	4
Consumption of coal from size of engines	138	Distribution boards	216
Convection of heat	132	Double beat valve	47
Cover or lap of slide valve ...	119	Double acting air pump	51
Corrosion on tail end shaft ...	87	Double bottoms, bad air in ...	148
Coupling for shaft	153	Double bottoms, bilge water in ...	149
Cracked tube plates	14	Draught; funnel	21
Cranes, hydraulic	231	Draught, forced	141
Crank shaft made of separate pieces, reason for	155	Draught, induced	142
Crank shaft made all of one size, reason for	155	Drain cocks	38
Crank webs, securing to shaft ...	156	Drain cocks, use of with water gauge	161
Cushioning, excessive	114	Driving air and water from condenser	65
Cushioning	117, 122	Dry uptake	16
Cut outs	223	Dry steam, how obtained	17
Cutting off steam, how done ...	115	Duty of expansion cylinder cold air freezer	194
Cylinder drain cocks	38	Dynamo, description of	211
Cylinder escape valve, protecting, etc.	38	Dynamo, what used for	211, 214
Cylinder to which blow through valve is fitted	64	Dynamo, styles of field windings	213-214
Cylinder escape valve, water left by	74	Dynamo, difference between it and a motor	215
Cylinder, air expansion	194	Dynamo, armature of	211
Dampers	36	Dynamo, commutator for	211-212
Damage to engines by freezing ...	133	Dynamo, brushes for	212
Danger with internal pipes in boilers	160	Dynamo, fixing in a cool place ...	227
Danger of sparking	220	"Earth" on electric circuit	219
Danger of short circuiting	220	Eccentric, loose	45
Danger of leading electric wires through bunkers	228	Eccentric rod, travel of	46
Deadweight safety valve	23	Eccentric rods on paddle wheels ...	78
Defective check valve	35	Eccentric, position of, for paddle wheel	79
Delivery and foot valves	53	Eccentrics for oscillating valve gear, position of	102
Density for working boilers, and how found	30	Economiser, with water-tube boiler	166
Depth pump will draw from ...	128	Economy of surface condenser ...	103
Detecting thin places in boilers ...	12		
Deterioration due to rusting, etc. ...	13		

	PAGE		PAGE
Edward's air pump	54	Fahrenheit thermometer	130
Effect of leaky foot valve	59	Fastening stay ends	10
Effect of suddenly opening safety valve	25	Fastening condenser tubes	63
Effect of leaky bucket	59	Faults with relief rings on slide valve	45
Effect of omitting liner under eccentric foot	138	Faults finding of, in electric circuits	217
Effect of flood water on bilge boards	151	Feathering float paddle wheel	78
Effect of swabbing compressor rods	192	Features of arc lamp	222
Effect of reducing area of electric leads	227	Feed pump pet cock	63
Effective heating surfaces in boiler	133	Feed pump failing	65
Electric wires passing through cold holds	197	Feed escape valve	109
Electric lighting on board ship	215	Feed escape valve, where placed	110
Electric wires through bunkers, danger of	228	Feed regulator, automatic ..	172
Electric motor	215	Feed water heater	197
Electric leads, finding faults upon	217-219	Feed water heater, fittings on	200
Electric lamps	222	Feed water heater, temperature with	200
Electric lamps, candle power of	223	Feed pump, independent	203
Electric wires led above side scuttles	228	Feed pump, independent advantages of	204
Electrical questions	211-228	Feed filter	205
Electrical wiring plan for ship Plate XIII.	223	Feed filter, how cleaned	206
Electrical terms	223	Feed filter, what is removed therefrom	206
Electrical measuring instruments	228	Ferrules, wood for condenser tubes	64
Element and alloy, difference between	4	Felting on steam jacket	92
Engine, compound	40	Field magnets, use of	225
Engines stopped, valves to shut and open	66	Field magnet windings	211-214
Engines, heating up before starting	66	Filter feed, description of	205
Engines, disconnecting	80-81	Filter feed, how cleaned and what removed	206
Engines, damage to, by freezing	133	Filter feed, how to tell when wants cleaning	206
Escape valves on cylinders	38	Filtering material, what made of	207
Escape valves, class of pump requiring	157	Finding pitch of screw propeller	70
Escape valves on air vessels, or not	159	Finding back pressure in condenser	125
Escape valves, best position for ..	160	Finding temperature of cold holds	191
Evaporator, description of	207-210	Finding fault in electric circuit	217
Evaporator, fittings with	210	Fitting dynamo in a cool place	227
Evaporator, removal of brine from	210	Fittings on marine boiler	91
Evaporator, cleaning coils of	211	Fittings on feed heater	200
Examining oil motor	250	Fixing boiler tubes	13
Excessive cushioning, trouble with	114	Fixing stern tube	89
Excessive lead, trouble with	119	Fixing screw propeller on shaft	90
Exhaust lap of slide valve	120	Fixing time of exhaust	117
Exhaust lead	121	Flame at funnel top	21
Exhaust, fixing time of	117	Flaming coal	135
Exhaust steam of freezers, where led	195	Flash point of petroleum and of petrol	242
Expansion by heat	7	Floats of paddle wheels	77
Expansion valve, separate	42	Forced draught	141
Expansion joints and boxes	82	Forgings, steel where used	141
Expansion cylinder, cold air freezer	194	Foot valve, leaky, effect of	59
Explosive gas from bunkers	147	Fuel consumption per I.H.P. per hour	103
Explosive mixture	147	Fuel consumption, oil	103
Explosion in tank	147	Funnel draught	21
Explosion of compressed charge in oil motor	243	Function of air vessels	158
		Furnace bars	134
		Fuses blowing unduly	220
		Fuses, description of	221

	PAGE		PAGE
Gab pin and lever	46	Ice, temperature of	131
Galvanometer	218	Independent circulating pump ...	49
Gas in paraffin tank	147	Independent feed pump	203
Gas in bunkers	147	Independent feed pump, advantages	
Gauge, water	26	with	204
Gauge, pressure	28	Indicated horse power	113
Gauge, steam, pressure shown by	30	Intensity coil for ignition, oil motors	
Gauge dial vacuum	124		244-245
Gauge markings from atmospheric		Interceptor	67
pressure	126	Insulation of cold chambers ...	196
Geared engines	102	Instruments for measuring electricity	
Glass water gauge construction ...	26		228-229
Glass water gauge, test cocks with	23	Iron, cast, where used	I
Glass water gauge pipe connections	26	Iron, wrought, where used ...	I
Glass water gauge pipes, clothing of	161		
Glass water gauge pipes, cleaning of	161	Jacket, steam	92
Glass water gauge, use of drain cock	161	Jet condensers	60
Glass water gauge, loop in steam		Jet condensers less economical than	
pipe	162	surface	104
Glass water gauge, water suddenly		Joints, expansion	82
rising	163		
Glass water gauge, thorough testing		Kerr's anticipatory governor ...	55
of	163	Kind of oil used in internal com-	
Glow lamp, description of	222	bustion engines	242
Governors	55		
Governors, features of	234	Lamp, arc, description of	222
Guard for blow off cock	22	Lamp, glow, description of ...	222
Guide bar, pressure on which ...	140	Lap of slide valve, steam	119
Gun metal, where used	2	Lap of slide valve, exhaust ...	120
		Lead	118
Haystack boiler	108-109	Leaky boiler tubes	14
Heat, conduction of	131	Leaky boiler tubes, stopper for ...	35
Heat, convection of	132	Leaky foot valve	59
Heat, radiation of	132	Leaky bucket	59
Heat, expansion by	7	Left hand propeller	71
Heating engines before starting ...	56	Lock up safety valve	23
Heating surfaces, effective, in boiler	133	Lignum vitæ bearing for stern tube	89
Height of water in air pump ...	69	Link motion	42
Holding down bolts of thrust		Lips on safety valves	26
slack	155	Loading of feed escape valve ...	109
Hooked bolts for paddle floats ...	76	Loose eccentric	45
Horse power, meaning of	113	Loop in steam pipe of water gauge	162
Horse power, nominal	113	Limit of temperature in hot well ...	60
Horse power, shaft	113	Liner on tail end shaft	87
Horse power, variation of thrust		Liner omitted, effect of	138
with	154	Lubricator, steam	74
Horse power, to operate rudder ...	233	Lunette evaporator	209-210
Hot well temperature	60		
How to tell if propeller is slack ...	140	Magneto ignition for oil motors ...	245
How to tell if trunnions are fair ...	140	Manometer	145
How to tell if shafting is fair ...	140	Material for pillars, struts, etc. ...	4
How air is lowered in temperature		Material for air pump rods	68
in cold air freezer	194	Material for paddle wheel rubbing	
How to clean feed filter	206	surfaces	80
How to tell when filter requires		Material for geared engine wheel	
cleaning	206	teeth	102
Hydrokineter, Weir's	107	Maximum density for working	
Hydrokineter, principle of	108	boilers	30
Hydraulic accumulator	228-231	Maximum pressure in compressor	
Hydraulic system, difficulty with,		NH ₃ machine	186
in cold weather	231		

	PAGE		PAGE
Maximum pressure in compressor		Oil motors, how explosion is effected	
CO ₂ machine	189	in	243
Maximum pressure in compressor		Oil motors, how started	246
cold air machine	195	Oil motors, how speed is varied	246
Mean effective pressure, how found	122	Oil motors, how reversed	246
Meaning of horse power	113	Oil motors, steps to take before	
Measure of horse power	113-114	examining with lights	250
Measuring intensity of draught	145	Oil motors, how frequently over-	
Metals capable of forging	6	hauled	250
"Michel" thrust	86	Oil tubes for thrust blocks	85
Mild steel, where used	1	Omitting liner, effect of	138
Minus lap of slide valve	121	One boiler getting more feed than	
More continuous discharge from		the other	134
single acting pump	99	Opening up of oil motors, frequency	
Most effective heating surfaces	133	of	250
Most efficient freezing agent	181	Oscillating engine	101
Mud box and why necessary	99	Oscillating engine valve gear	101
Muntz metal, where used	2	Oscillating engine valve gear,	
		position of sheaves for	102
Need for greater strength in longi-		Paddle wheel, common or radial	76
tudinal seams	9	Paddle wheel, cast iron floats	77
Need for expansion joints	82	Paddle wheel, floats of different	
Need for check nuts on expansion		breadths	77
joints	83	Paddle wheel, feathering	78
Newcastle and Welsh coal, com-		Paddle wheel, eccentric rods for	78
parison between	135	Paddle wheel, hooked bolts for	
Nickel steel, where used	141	floats	76
No feed escape valve, check valve		Paddle wheel, material of rubbing	
when	112	surfaces	80
Nominal horse power	113	Paraffin tank, gas and explosion in	147
Non-conducting substances	105	Parallel wiring	215
		Parallel series wiring	216
Object of air pump pet cock	59	Parsons turbine	174
Object of feathering paddle floats	78	Parts of boiler injured by shortness	
Object of lead	118	of water	18
Object of steam lap	119	Parts for which wrought iron is	
Object of exhaust lap	120	used	1
Object of reducing valve	169	Parts for which cast iron is used	1
Objection to moisture in NH ₃		Parts for which steel is used	1
freezer	184	Parts for which gun metal or brass	
Objection to moisture in CO ₂		is used	2
freezer	188	Parts for which white metal is used	2
Objection to moisture in cold air		Parts for which muntz metal is used	2
freezer	195	Parts of engine that are felted	93
Ohm	223	Pet cocks	59, 63
Oil cup	84	Petrol, flash point of	242
Oil cup, worsted for	84	Petrol, calorific value	242
Oil fuel consumption	103	Petrol, specific gravity of	242
Oil consumed with Diesel engine	103	Petroleum, flash point of	242
Oil fuel, smoke with	106	Petroleum, calorific value of	242
Oil fuel, consumption with	136	Petroleum, specific gravity of	242
Oil motor questions	237-250	Pieces through which effort of steam	
Oil motors, principal parts of	237	is conveyed	96
Oil motors, cam shaft	239	Pitch of propeller	70
Oil motors, carburettor	239	Pipes in connection with engines	
Oil motors, silencer	240	and boilers	95
Oil motors, piston	239	Pipes through which circulating	
Oil motors, valves and sparking plug	239	water passes	96
Oil motors, fuel used with	242	Pipes through which feed passes, jet	
Oil motors, storage of fuel	242	condenser	96
Oil motors, number of cylinders in	243		

INDEX

319

	PAGE		PAGE
Pipes through which steam passes, surface condenser ...	97	Reason for making crank shaft all one size ...	155
Pipe connections for water gauge ...	26	Reason for fitting escape valve to pumps ...	157
Piston, construction of ...	37	Reaumur thermometer ...	130
Piston air pump ...	50	Rectifier, use of ...	193
Piston slide valve ...	116	Reducing friction of slide valves ...	44
Piston slide valve, how kept tight ...	117	Reducing valve ...	169
Piston for oil motor ...	239, 243	Refrigerating machines where exhaust is led ...	195
Piston, how many in oil motors ...	243	Refrigeration ...	180-197
Plates worked hot ...	7	Refrigeration, cold air process of ...	193
Plugs in steam piston ...	37	Refrigeration, CO ₂ process ...	188
Plunger air pump ...	50	Refrigeration, NH ₃ process ...	180
Position of eccentric for paddle wheel ...	79	Relief rings ...	44
Position for working sluice valve ...	91	Repairing cracked tube plate ...	14
Position of fault in electric circuit, finding ...	217-219	Resistance coils ...	225-226
Precautions with stop valve when raising steam ...	67	Resistance of circuit increasing ...	227
Precautions in cold climates ...	134	Resistance to rudder coming back ...	232
Precautions to take before removing boiler manhole ...	234	Resistance felt by steersman ...	232
Precautions in storing petrol and petroleum ...	242	Resistance depending on area of rudder, etc. ...	232
Preventing priming ...	18	Reversing with oil motor ...	246
Preventing racing ...	69	Reversing gear, description of ...	247-250
Preventing cylinder condensation ...	92-93	Right hand propeller ...	71
Preventing radiation ...	105	Riveting, strongest ...	9
Preventing smoke ...	106	Riveted stays ...	12
Pressure gauge, Bourdon ...	28	Rose, large, advantage over small ...	149
Pressure of the atmosphere ...	115	Rubbing surfaces of paddle wheel ...	80
Pressure, mean effective, how found ...	122	Rudder, what holds it ...	232
Pressure of air in Merchant Service boilers ...	145	Rudder, horse power to operate it ...	233
Pressure on thrust, variation in ...	154	Safe working stress ...	5
Pressure higher in boiler than in engines ...	168	Safety valve, deadweight ...	23
Pressure, maximum, with CO ₂ freezer ...	189	Safety valve, rubbing surfaces ...	23
Pressure, maximum, with NH ₃ freezer ...	186	Safety valve, spring loaded ...	25
Pressure, maximum, with cold air freezer ...	195	Salinometer ...	33
Proof stress ...	6	Salinometer, what it records ...	34
Propeller, pitch of ...	70	Salting of boiler ...	30
Propeller, slip of ...	72	Scale ...	32
Propeller, fixing of ...	90	Screw propeller, pitch of ...	70
Propeller, to tell if slack ...	140	Scum cocks, etc., ...	31, 160
Properties, different, of irons and steel ...	4	Securing webs to shaft ...	156
Pump, circulating ...	48	Self-acting valves ...	72
Pump, air ...	50-51	Sending exhaust steam through filter ...	105
Pump, centrifugal ...	51	Series wiring ...	215
Pump fitted with escape valve, class of ...	157	Series parallel wiring ...	216
Quadrant with oscillating engine valve gear ...	102	Separate expansion valve ...	42
Racing of engines ...	69	Shaft horse power ...	113
Radiation, minimising ...	93	Shaft to tell if fair ...	140
Radiation of heat ...	132	Shaft coupling ...	153
Reason for making crank shaft in pieces ...	155	Shortness of water, dangers from ...	18
		Short circuiting, what it is ...	220
		Short circuiting, dangers with ...	220
		Should cocks, etc., be fitted to air vessels ...	155
		Silencer for oil motor ...	246
		Single wire, hull return system of wiring ...	217
		Single wire, hull return, faults with ...	217
		Sketches of air vessels ...	158

	PAGE		PAGE
Slide valve, reducing friction of ...	44	Stern tube	88-89
Slide valve, lead of	118	Stern tube lignum vitae bearing ...	89
Slide valve, lap of	119	Stopper for tube	35
Slide valve, exhaust lap of ...	120	Stores list	151
Slide valve, minus lap of ...	121	Storing petrol and petroleum, pre-	
Slip of propeller	72	cautions in	242
Sluice valves	91	Stress, safe working	5
Smoke preventing	106	Stress, proof	5
Smoke, temperature of	131	Stress, breaking	5
Soda in a boiler	73	Stress allowed upon stays	11
Space between furnace bars ...	134	Struts, pillars, material for ...	4
Sparkling, dangers of, etc., ...	220	Surface condenser, economy with ...	103
Sparkling, how caused	220	Surface condenser, construction of	104
Sparkling plug for oil motor ...	239	Surface condenser, repairing split	
Specific gravity of petrol and		tube	104
petroleum	242	Surface condenser, how cleaned and	
Speed of piston	114	where foul	105
Speed of ship, variation in thrust		Superheater	17
with	154	Swabbing compressor rods, effect of	192
Split tube, stopper for	35	Switches, use of	223
Split tube in condenser	104	Syphon pipe for pressure gauge ...	28
Spring loaded safety valves ...	25	System of electric lighting on board	
Square foot, unit for air pressure	146	ship	215
Star disc with paddle wheel ...	78-79	Tail end shaft	87
Starting of oil motors	246	Tallow cup	73
Stay ends, securing of	10	Tanks, ballast, bad air in	148
Stays, stress allowed upon ...	11	Tempering steel	5
Stays, riveted, description of ...	12	Temperature of hot well	60
Stay tubes	13	Temperature of cold holds, finding	191
Steam pressure gauge	28	Temperature with feed heater ...	200
Steam piston, construction of ...	37	Temperature at which to use salino-	
Steam lubricator	74	meter	33
Steam trunnion for oscillating engine	83	Temperatures noted by engineers ...	48, 129
Steam jacket	92	Temperatures of ice, water and steam	131
Steam, cutting off	115	Test cocks	23, 160
Steam, temperatures of	131	Thermometer	129
Steam, difficulty of keeping with a		Thickness of furnace bars	134
heavy list	150	Thin places in boilers	12
Steam turbine, Parsons	174	Thrust bearing or block	85
Steam turbine, path of steam through	174	Thrust where applied to ship, screw	
Steam turbine, propellers with ...	174	steamer	102
Steam turbine blading	175	Thrust where applied to ship, paddles	103
Steam turbine dummies	176	Thrust, variation in pressure of ...	154
Steam turbine carbon packing ...	178	Tons of coal per day, from area of	
Steam turbine geared	177	grate	135
Steam turbine, difference between it		Tons of coal per day, from size of	
and reciprocator	178	vessel	137
Steam turbine, power to go astern ...	179	Tons of coal per day, from size of	
Steam turbine, consumption with ...	179	engines	138
Steam hydraulic accumulator ...	228-231	Top and bottom ends running hot ...	155
Steam steering gear	231	Total pressure of steam	30
Steel forgings, where used	141	Travel of the eccentric rod	46
Steel nickel, where used	141	Triple expansion engine, what it is	40
Steel, where used in engines ...	1	Trunk air pump	51
Steel, where used	1	Trunk engine	99
Steel, tempering	5	Trunnions to tell if fair	140
Steering gear, steam	231	Tube plates, cracked	14
Steering gear, steam, preventing		Tube stoppers	35-36
rudder coming back	232	Tubes, boiler, fixing	13
Steering gear, steam, what resistance		Tubes, "stay"	13
man feels	232		

	PAGE		PAGE
Turbine, fuel consumed with ...	103	Water gauge test cocks ...	23
Turbine, blading ...	174	Water gauge construction ...	26
Turbine, expansion of steam with ...	174	Water gauge pipe connections ...	26
Turbine, how many propellers and shafts ...	174	Water gauge pipes, clothing of ...	161
Turbine "dummies" ...	176	Water gauge pipes, cleaning of ...	161
Turbine, thrust with ...	176	Water gauge, use of drain cock ...	161
Turbine, geared ...	176-178	Water gauge loop in steam pipe ...	162
Turbine, difference between it and a reciprocator ...	178	Water gauge, thorough testing of ...	163
Turbine, power available to go astern with ...	179	Water gauge, water rising suddenly ...	163
Turbine propellers, what made of	179	Water left in cylinder ...	74
Turbine consumption with ...	179	Water in hot well, temperature of ...	131
Two-wire system of ship wiring ...	217	Water in one boiler more than another ...	134
U gauge for air pressure ...	145	Water, effect on bilge boards of flood	151
Uptakes, wet and dry ...	16	Water, amount it can be compressed	160
Use of rectifier ...	193	Water-tube boiler, construction of ...	166
Use of dynamo ...	214	Water-tube boiler, Babcock & Wilcox ...	165-166-167
Vacuum gauge ...	124	Water-tube boiler, economiser with	166
Vacuum, what is meant by "so many inches" ...	128	Water-tube boiler, gauge glass fitting	168
Vacuum, what it is ...	129	Water-tube boiler, higher pressure steam with ...	168
Vacuum in boiler, dangers with ...	234	Water, objection to, in NH ₃ freezer	184
Valve, deadweight safety ...	24	Water, objection to, in CO ₂ freezer	188
Valve, spring loaded safety ...	25	Water, objection to, in cold air freezer ...	195
Valve check, defective ...	35	Watt ...	223
Valve, separate expansion ...	42	Webs to shaft, securing ...	156
Valve, double beat ...	47	Weight of the atmosphere ...	115
Valve air, for circulating pump ...	50	Weir's feed heater ...	197
Valves for air pump ...	53	Weir's feed pump ...	203
Valve, foot, leaky ...	59	Weir's evaporator ...	207
Valve, blow through ...	64	Weir's hydrokineter ...	107
Valve, pet ...	63	Welding ...	6
Valves to shut and open, engines stopped ...	66	Welsh coal, more air with ...	135
Valves, self-acting ...	72	Wet uptake ...	16
Valve gear with paddle engines ...	81	What a salinometer records ...	34
Valves, sluice, where placed ...	91	What a triple compound engine is ...	40
Valves and cocks on skin of ship ...	91	What is used for air pump rods ...	68
Valves and cocks to open before starting ...	92	What would happen if no mud box fitted ...	99
Valves and cocks through which feed passes, jet condenser ...	96	What is meant by circulation in a boiler ...	107
Valves and cocks through which feed passes, surface condenser ...	97	What a vacuum gauge is used for ...	124
Valves and cocks through which circulating water passes ...	96	What limits depth pump can draw from ...	128
Valves for oil motor ...	239	What furnace bars are made of ...	134
Valve gear for oscillating engine ...	101	What governs size of crank shaft ...	156
Valve feed escape ...	109	What takes the place of an ash ejector	201
Valve air pump discharge ...	110	What is done by steersman when operating wheel ...	233
Valve check, unadjustable ...	112	Where wrought iron is used ...	1
Valve, reducing ...	169	Where cast iron is used ...	1
Variations in gauge readings ...	127	Where steel is used ...	1
Variations in thrust pressure ...	154	Where brass or gun metal is used ...	2
Variations of speed in oil motor ...	246	Where white metal is used ...	2
Volt ...	223	Where muntz metal is used ...	2
Voltmeter ...	228	Where strongest riveting is used ...	9
		Where sluice valves are placed ...	91
		Where mud boxes should be placed	99
		Where air vessel should be placed	98

	PAGE		PAGE
Where thrust is applied to ship, screw propeller	102	Wheel, paddle, feathering float ...	78
Where thrust is applied to ship, paddles	103	Which guide bar has greatest pressure	140
Where feed escape valve should be placed	110	White metal, where used	2
Where steel forgings are used ...	141	Why a square foot is the unit for air pressure	146
Where nickel steel is used ...	141	Why gas accumulates at fore end of holds	148
Where gas accumulates in holds and why	148	Wood ferrules for condenser tubes	64
Wheel, paddle, radial float ...	76	Working of engine with slack thrust	155
		Worsted for oil cup	84

**JAMES BROWN & SON,
THE NAUTICAL PRESS,
GLASGOW.**

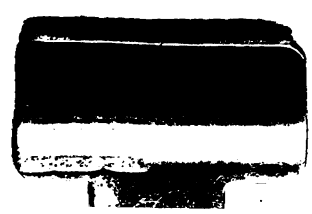
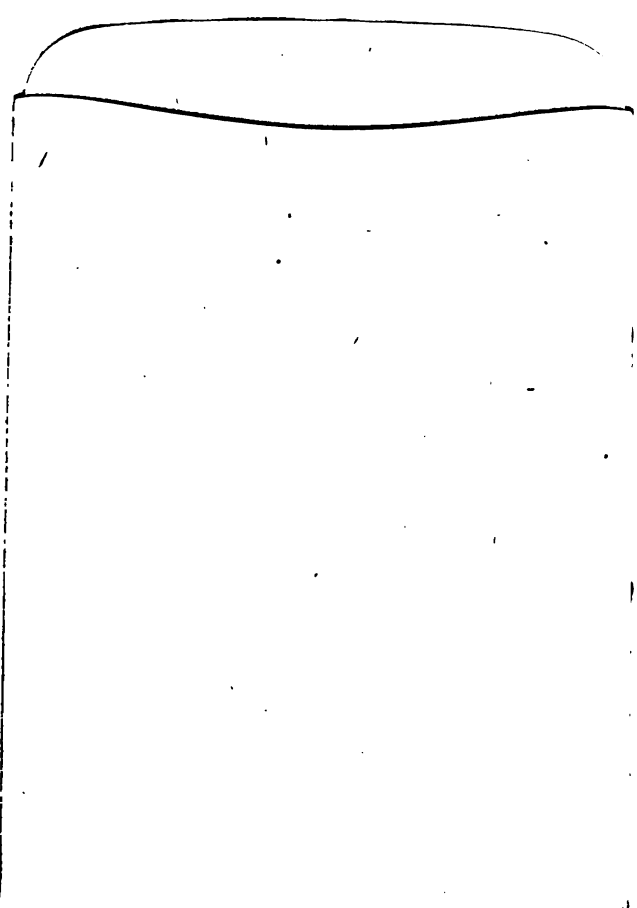
89089677272



B89089677272A

This book may be kept

1



1

89089677272



b89089677272a